PHILIPSTOWN INVENTORY REPORT · 2020

SINK, STORE, REDUCE, OFFSET

An innovative GHG inventory and its implications for achieving local carbon neutrality.

ECO LOGICAL CITIZEN'S PROJECT

I·C·L·E·I Local Governments for Sustainability USA

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The ***Philipstown Climate Smart Community Task Force***, a group of dedicated volunteers who provided invaluable input during the planning stages of this inventory, cheering our Town on toward innovation rather than the status quo.

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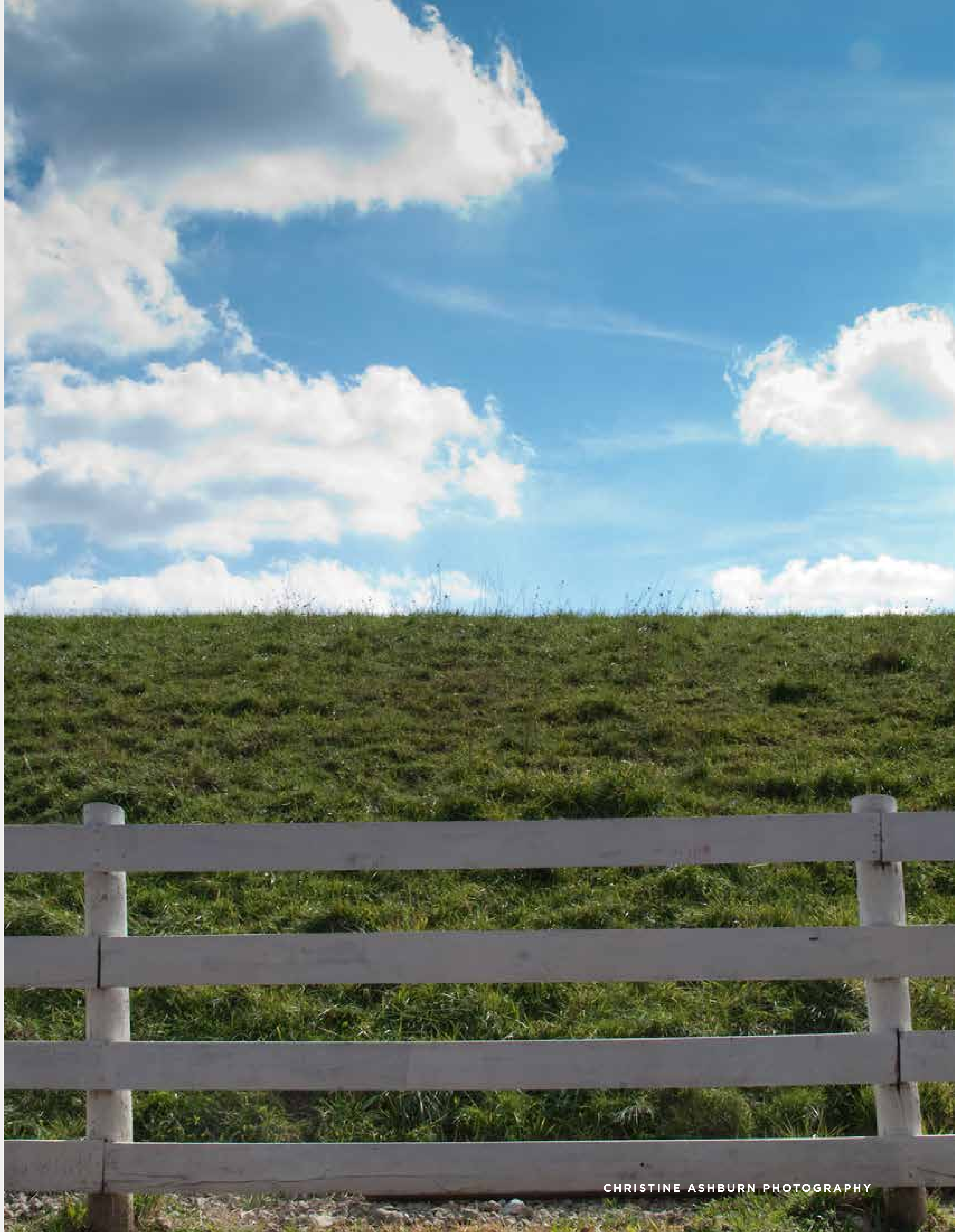
Dear Philipstown community members,

Every journey begins with setting a destination. Even before that, one needs to know where they are. It is from this fundamental precept that the Town of Philipstown has embarked on the journey to aid in work of slowing climate change. Without our help and the work of everyone on the planet, the future is uncertain at best. And so, with this in mind, we have set about to do our part by lowering our greenhouse gas emissions and in doing so shrink our emissions footprint. Why is this important? Greenhouse gases trap heat in the atmosphere and are the leading cause of temperature rise on earth. This temperature rise is the cause of many problems for the planet, including the melting of the polar ice caps, sea level rise, floods and drought. Many people around the world are experiencing the negative effects of these issues right now.

What can we do? Collectively as a community we are committing to lowering our greenhouse gas emissions. In order to achieve our goal we will set out on a journey. Together we will move toward creating a town that lowers its emissions as far as we can with the ultimate destination of zero. In order to do that we need to know where we are now. That is why it is important to know how much GHG we are currently emitting as a community so that we can have a starting point against which to measure our progress. The document that is being produced by our Climate Smart Task Force is the Greenhouse Gas Inventory Report. This will be the map for our journey to a brighter, more sustainable future for all of us and for future generations. Please join us on our journey to save the only planet we have.

Thank you,

Richard Shea, *Philipstown Supervisor*



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Dear Neighbors,

We expect that if you take some time to read the results of this community inventory of greenhouse (GHG) emissions, you will be at first depressed, a bit surprised, and hopefully begin to see the opportunities to build a better community if we rise to meet the challenges we are all faced with.

This inventory attempts to measure all of the emissions created through the production, distribution, and disposal of the goods and services we purchase and consume. It reveals clearly how our participation in a fossil-fuel powered, global, disposable, consumption-driven economy feeds the fires of climate change. After the shock of the coronavirus pandemic, it also reminds us that the new world we must create should be built on a more resilient foundation of secure access to local food, a durable and prosperous local economy, and a more socially connected community. The status quo is not acceptable. We have the work of regeneration ahead of us.

At the same time, this is one of the first local GHG inventories in New York State that attempts to measure the work of nature around us — our forests, wetlands, and fields — to remove and store carbon from the atmosphere. By looking at both sides of the ledger, emissions and natural carbon removals, it is hard to ignore the reality that our way of life is out of balance with the natural world that supports life on our planet.

There is no more time to wait, for the clock is already against us and we will be judged by what we did when faced with the truth of our situation. We cannot wait for others to act for us, for while international and national policy change will be critical, at the end of the day real people living in local communities everywhere will be the ones who must make change happen.

While no inventory that attempts to measure the complexity of living systems can ever claim to be exact, this inventory helps us identify where change can be most effective. Ours can be a future where improving personal and community health means fighting climate change. A future where building a local food system and spending our money in local businesses means fighting climate change. Where each of us can plant a tree, or a garden, or protect a wetland to join the side of nature in protecting human life. The future we can build can be defined not by scarcity, but by an abundance of the things that matter most.

AS ACTIVIST ED WHITFIELD HAS WRITTEN,

"Our full humanity is tied up in not just resisting power, not just directing other people with power, but ultimately being the power ourselves, to meet our needs and to elevate the quality of life in our community for ourselves and the people we care about."

The world at this moment needs living examples of communities that have found a balanced way to live. And if not Philipstown — with our love of nature, numerous community organizations and civic spirit, and relative affluence and economic means — then who?

We have a single generation to get this work done. Only together can it be accomplished. We hope you will join the effort.

— Jason Angell and Jocelyn Apicello, *Ecological Citizen's Project*

PHOTO BY ANNIE SPRATT ON UNSPLASH

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Glossary of Key Terms

Carbon-dioxide equivalent: This report often refers to carbon-dioxide equivalent (CO2e) values, and particularly metric tons of this unit, noted as MTCO2e. In greenhouse gas emissions inventories, the primary gases are mostly quantified by the number of metric tons contributed to the atmosphere. Meanwhile, each gas warms the atmosphere to a varying degree. In order to express this cumulative contribution from a mixture of greenhouse gases, each gas is reported by its relative warming in relation to carbon dioxide, allowing for a single “carbon-dioxide equivalent” value.

Carbon negative: A situation where carbon removals are greater than carbon emissions.

Carbon sequestration: Removal of CO2 from the atmosphere. This most often happens through photosynthesis in plants and through ocean processes, such as metabolic processes of aquatic life. Also known as carbon sinking. Also referred to as carbon removal.

Carbon storage: Carbon that is held in a pool other than the atmosphere, such as living plant biomass, soil carbon, or long-lived wood products. Disturbance of ecosystems with stored carbon can lead to significant CO2 emissions. Also known as a carbon stock or pool.

Consumption-based accounting: a greenhouse-gas emissions-accounting methodology that calculates emissions at the point of consumption, attributing all the emissions that occurred in the course of production and distribution to the final consumers of goods and services. Consumption-based accounting is a nascent methodology that shows promise for including considerations for our global flows of goods and services in traditional GHG inventories.

Direct emissions: Greenhouse gas emissions that occur within the geographic boundary for a community inventory.

Downstream emissions: emissions that occur after the use phase in the life cycle of a product, material or energy source. Downstream emissions are primarily associated with disposal, such as landfilling or incineration of solid waste.

Greenhouse gas: A greenhouse gas (GHG) acts to warm the Earth’s surface by preventing heat from being radiated to space. Human activities since the industrial revolution have greatly increased concentrations of several of these gases. Carbon dioxide (CO2) is the most significant, though methane (CH4) and nitrous oxide (N2O) as well as HFCs are also important contributors to warming.

Indirect emissions: Greenhouse gas emissions that occur outside of the geographic boundary.

Net-zero emissions: A situation where emissions are balanced by greenhouse gas removals. Also known as carbon neutral.

Production-based accounting: a greenhouse-gas emissions-accounting methodology that prioritizes calculating emissions-generating activities within the geographic boundary of a particular jurisdiction. The jurisdictional boundary is limited to the location where goods and services are produced. This methodology is more standardized in global practice, notably through the *US Community and Global Protocols for GHG Emissions Inventories.*

Scopes Framework: GHG accounting protocols divide emissions into three categories, called scopes. Scope 1 includes all direct emissions, such as fuels burned in buildings or vehicles within the community. Scope 2 is for emissions from electricity use. Scope 3 is for all other indirect emissions. Typical scope 3 emissions in a community inventory include emissions from solid waste sent to landfills outside the community, community use of air travel, and emissions to produce materials, goods and services used in the community.

Upstream emissions: Greenhouse gas emissions that occur before the use phase in the life cycle of a product, material or energy source. Upstream emissions can include those from extraction of raw materials, processing and manufacturing, and transportation along each step of the supply chain.

List Of Figures, Tables, Appendices

Executive Summary

In October 2018, the United Nations Intergovernmental Panel on Climate Change (IPCC) found that to avoid the worst consequences of climate change global society will have to limit warming below 1.5°C by achieving carbon neutrality — when human-caused greenhouse gas (GHG) emissions are balanced by human-caused emissions removed from the atmosphere — by 2040.

Given the uncertainty of sufficient international or federal action and the urgent time frame, we must explore all options to address climate change locally. What does the path to carbon neutrality look like at the local community level? This report is the product of nearly two years of work, the result of a collaboration between Hudson Valley scientists, community leaders, and volunteers to produce the Town of Philipstown's first community carbon inventory and reflect on its implications for achieving local carbon neutrality.

This innovative inventory is one of the first in New York State to use real local data to measure the full life-cycle carbon emission impacts of the goods and services our residents consume and to estimate the work of our natural resources to remove and store carbon from the atmosphere. We hope this report helps create a data-based Climate Action Plan (CAP) toward carbon neutrality for the Town of Philipstown by 2040 and serves as a roadmap for other local communities of how we all can take transformative action to meet humanity's greatest challenge.

COMMUNITY GHG EMISSIONS

As opposed to the standard inventory approach which measures only the emissions produced within a community's geographic boundaries, a consumption-based inventory also localizes the global problem of climate change by accounting for the emissions produced as a result of our purchase of goods and services. The consumption-based estimates of our emissions are 83% higher than our production-based estimates and reveals how essential shifting our purchasing behaviors to support stronger local economies will be to achieving carbon neutrality.

Total emissions for the consumption-based inventory were calculated at 198,703 metric tons of carbon-dioxide equivalent (MTC02e) for the Town of Philipstown, which translates to 55.5 MTC02e per household or 20.4 MTCO2e per person. The top five emission categories in the consumption-based inventory are responsible for nearly 90% of the Town of Philipstown's community-wide emissions. The leading source of emissions result from residents purchase and consumption of services (led by health services, which account for 10% of national GHG emissions), food (driven by beef consumption and a globalized food chain), home heating (due to use of fossil fuel powered heating and cooling), on-road transportation (due to use of fossil fuel powered vehicles) and goods (driven by a globalized, disposable production system).

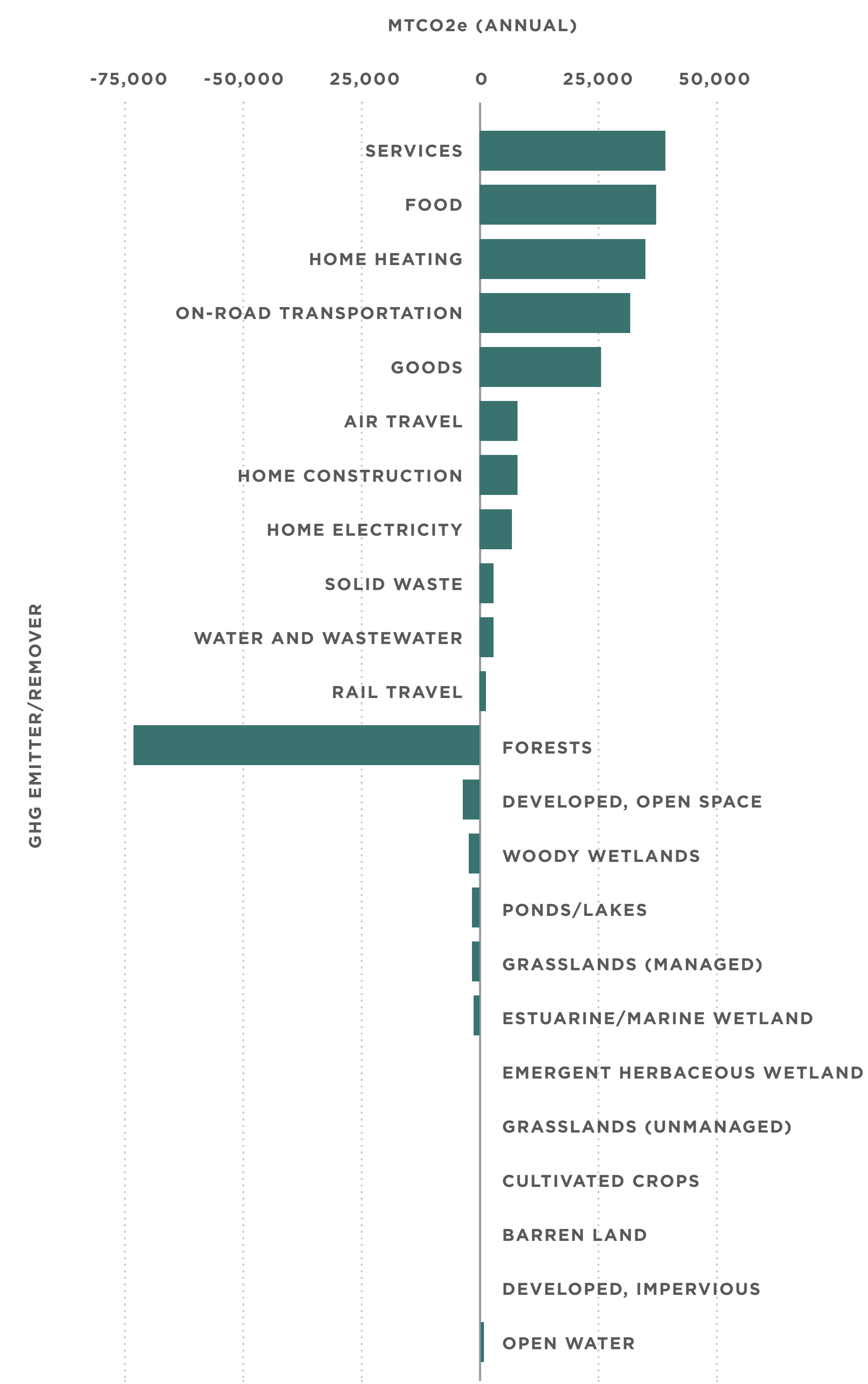
COMMUNITY GHG REMOVALS

Our forests (77.8% of Philipstown's acreage), lawns/fields (9.5%) and wetlands (5.0%) remove a great amount of carbon emissions from the atmosphere through the process of photosynthesis and store them back into the earth. The work these natural resources do to support ecological balance have been ignored at great cost. Working with local scientists, our inventory estimates that the Town of Philipstown's natural resources annually removes a total of between 79,036-86,098 MTC02e each year — equivalent to roughly 40% of our annual community-wide emissions. And even though wetlands comprise only 5% of Philipstown's land use, they store an amount of carbon that is equivalent to nearly twenty years of Philipstown's annual community-wide emissions.

Today, roughly half of Philipstown's forests and 36% of Philipstown's freshwater inland wetlands are currently protected or conserved. These estimates highlight that the loss of land uses like forest, wetland, or fields would be a source of significant new emissions that make the path to local carbon neutrality more difficult to achieve. Putting a value on ecosystem services introduces a powerful new tool for local communities to protect their natural resources, lays the groundwork for a future local carbon offset program, and reveals the vital caretaking role humans can play in increasing natural carbon sequestration and storage.

PHILIPSTOWN INVENTORY REPORT | 2020 | EXECUTIVE SUMMARY

TOWN OF PHILIPSTOWN EMISSIONS AND REMOVALS



THE WORK AHEAD

The United Nations IPCC report stated that "limiting global warming to 1.5°C requires rapid, far-reaching and unprecedented changes in all aspects of society." In order to reach carbon neutrality by 2040, each resident of Philipstown, on average, would have to reduce or offset their emissions by 1. MTC02e each year. The road to local carbon neutrality will call for significant changes in our personal behaviors, local public infrastructure and economy, and land use practices. While none of these proposed responses have been officially adopted by the Town of Philipstown, we believe they would make our community a national local leader in the fight against climate change:

- Establishing a dedicated local fund to support the carbon neutrality campaign;
- A community health initiative that promotes less need for health services, such as healthy eating, increased physical activity and non-motorized transportation opportunities, and increased social connections to reduce isolation;
- Reduced beef consumption and increased regenerative food production within the Town of Philipstown and sourcing of local foods by community grocers, restaurants, and institutions;
- Transition to fully electrified home heating, cooling, and personal vehicles for transportation, supported by a Community Choice Aggregation (CCA) that is estimated to have reduced local electricity supply GHG emissions by 97% compared to previous Central Hudson sources;
- Reduced housing stock emissions by a community energy efficiency campaign, updated local building codes, and encouraging the development of smaller, more efficient homes;
- Creation of a master plan for local economic development that incentives local goods production, encourages residents to purchase less generally and more local goods, and reduces goods waste;
- Prevented conversion of Philipstown's forests, wetlands and fields to developed space, in order to prevent the loss of our natural resource's annual carbon removals; and
- Establishing a Philipstown Civilian Conservation Corps (CCC) dedicated to reforestation, wetlands management, and a transition to regenerative soil practices

We recommend that the Town of Philipstown adopt the results of this consumption-based and land-use inventory as our official community baseline. As the Town's Climate Smart Community Task Force embarks on the work of developing a CAP that establishes targets to reduce or offset future GHG emissions, we recommend they adopt the goal of becoming a carbon neutral community by 2040 or a carbon negative community at an earlier target date if the Town decides land use, land use change and forestry carbon removals should count towards net emissions at the local level. Working together, we can demonstrate what it will take to build a more healthy, happy, connected and regenerative community.

CHRISTINE ASHBURN PHOTOGRAPHY

Introduction

AIMING FOR LOCAL CARBON NEUTRALITY

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) released the Special Report on Global Warming of 1.5°C (SR15). The report found that if humans are to limit warming to below 1.5°C — the goal set by the Paris Agreement adopted in 2015 based on scientific consensus to avoid devastating outcomes like increased food and water insecurity, loss of biodiversity, and declining human health and living standards — global society will have to achieve carbon neutrality or net-zero carbon dioxide (CO2) emissions by 2040. Carbon neutrality is achieved when human-caused greenhouse gas (GHG) emissions are balanced by human-caused emissions removed from the atmosphere.

In July 2019 New York passed the Climate Leadership and Protection Act ("Climate Act"), the most ambitious climate targets in the country calling for economy-wide, net-zero CO2 emissions by 2050 by cutting emissions by 85% from 1990 levels and offsetting the remaining 15% through human activities that remove or sequester carbon from the atmosphere. The Climate Act defines GHG emissions as those that are produced within the state by human activities and those emissions produced outside of the

PHOTO BY JEFFREY BLUM ON UNSPLASH

state associated with the generation of imported electricity. In addition, the Climate Act may require that allowable carbon offset activities occur within 25 miles and the same county as the source of the emissions, creating the opportunity for local communities to be paid for initiating activities that remove carbon from the atmosphere.[1]

While the Climate Act is a great legislative achievement, it also reveals a flaw in conventional approaches to measuring emissions and setting climate targets. Even if New York meets its ambitious goals and reduces emissions produced within the state to net-zero by 2050, it will have done little to reduce the emissions that are produced around the world as a result of the production, distribution, and disposal of the goods and services individual New Yorkers purchase and consume.

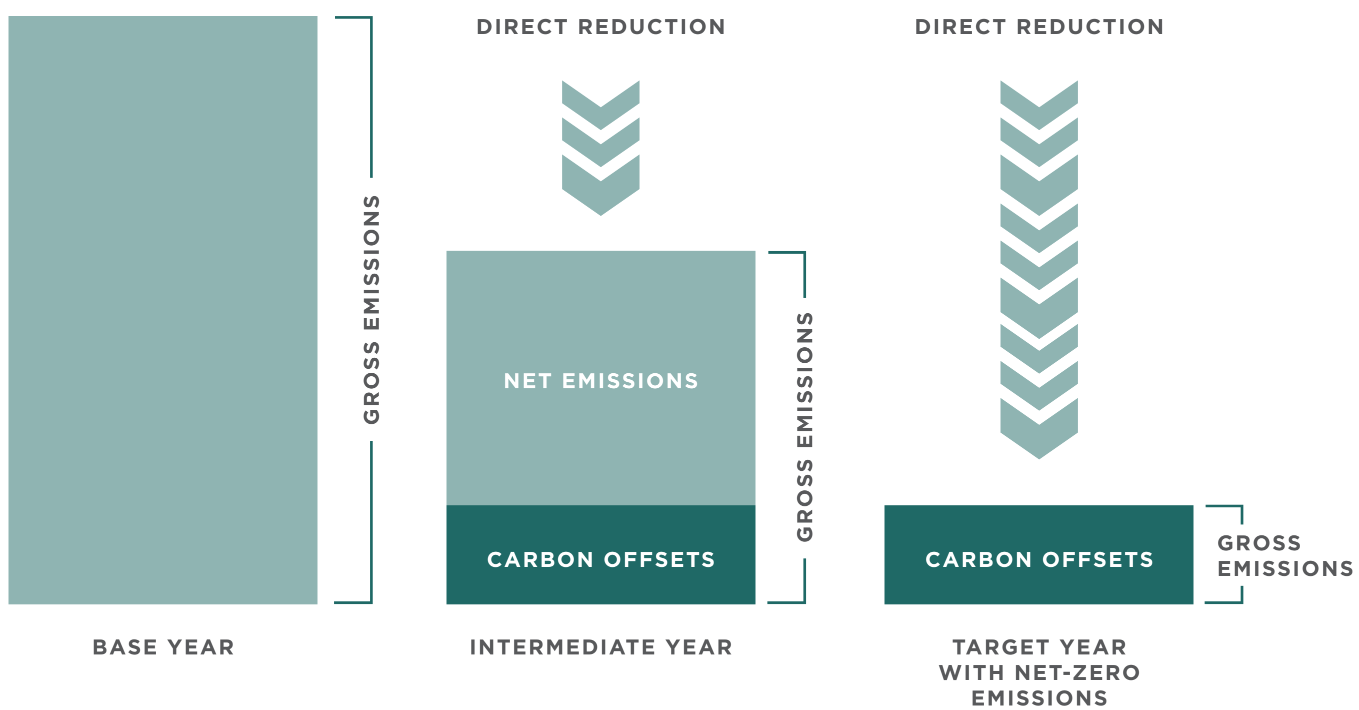
Climate change is a global problem. Yet as international climate negotiations fail to commit to necessary and measurable progress — with both 2019's United Nations Secretary General's Climate Summit and the UN climate body's Conference of the Parties, or COP25, as recent example — these looming catastrophic deadlines mean that local communities no longer have the luxury of sitting on the sidelines and waiting for national or international actors to "solve the problem." This report is a result of the belief that we need to localize the fight against climate change, revealing how the decisions we have the power to make within our local communities can result in the global emissions reductions needed to reach global carbon neutrality by 2040.

[1] Intergovernmental Panel on Climate Change. Global warming of 1.5C. (2019). Retrieved from: https://www.ipcc.ch/sr15/

As the old bumper sticker proclaims, “Think globally, act locally.” While averting a climate crisis will require historic global collaboration and policy-making, the fact is that GHG emissions are released into the atmosphere (and can be removed from it) at the local level. Philipstown might consider aligning its goals with New York’s Climate Act and the global movement towards carbon neutrality by seeking to reduce community-wide emissions from both direct and indirect sources 85% by 2040 and by offsetting the remaining 15% through carbon removal or sequestration activities in Philipstown and beyond (Figure 1).

The data in this report makes clear that we will have to transform the ways we move around, build and heat our homes, produce our electricity, consume food and other goods and services, and make land-use decisions. And we will have to do it within the span of a single generation, working together with common purpose across all of the varying lines that divide us. We hope this report provides committed local communities and individuals with better tools to create data-based road maps to carbon neutrality, joining the global movement to protect our common home.

FIGURE 1. COMMUNITY CARBON NEUTRALITY



Source: C40 Cities, Defining carbon neutrality for cities & managing residual emissions.

BECOMING A CLIMATE SMART COMMUNITY

In 2009, New York State’s Department of Environmental Conservation created the Climate Smart Communities program to help local governments take action to reduce GHG emissions (referred to as mitigation) and adapt to a changing climate (referred to as adaptation). In June, 2017, the Town of Philipstown adopted the state’s Climate Smart Communities Pledge and convened a task force of local community members to develop a local Climate Action Plan (CAP) that outlines the policies and actions local government, community partners, and individuals will take to reduce emissions and adapt to unavoidable climate change.

An important first step for any community to address climate change is to assess the amount of carbon emissions the local community is responsible for releasing into the atmosphere. The Town of Philipstown completed its municipal operations emissions inventory in April 2019. While measuring the emissions that result from local government operations is an important step, these emissions typically account for less than 3% of a community’s overall emissions.[2] Any realistic effort to mitigate climate change locally requires conducting a community-wide inventory of emissions, forecasting emissions growth over time, and developing a monitorable CAP to reduce future emissions across both local government operations and the entire community.

In August 2018, the Town of Philipstown became a member of ICLEI-Local Governments for Sustainability USA (ICLEI), the leading international network of cities and towns advancing sustainability. The Ecological Citizens Project, Inc., a nonprofit located in Philipstown that works to develop community campaigns to build a more just, healthy, democratic and sustainable way-of-life, helped raise private funds to secure a public matching grant from the Mid-Hudson Regional Economic Development Council to develop and implement an innovative community inventory in collaboration with the Town of Philipstown Climate Smart Community task force and ICLEI. For nearly two years, we have worked with local partners to develop New York’s first community greenhouse gas (GHG) inventory to measure community-wide emissions using both a geographic, or production-based, approach and a consumption-based approach that measures the life-cycle emissions of goods and services purchased, while also accounting for the carbon storage and sequestration work of our natural resources.

It is our hope that this report will help create a data-based roadmap toward carbon neutrality for the Town of Philipstown and serve as a model for other local communities of how we all might take action to meet humanity’s greatest collective challenge.

[2] Climate Smart Communities. Certification action. (n.d.). Retrieved from: https://climatesmart.ny.gov/actions-certification/actions/#close

DETERMINING WHAT TO MEASURE IN A GREENHOUSE

GHG Emissions Inventory

Before undertaking its community-scale GHG inventory, a community must make important decisions about what to measure, what the boundary area of the inventory will be, and what data sources to use to create the most accurate baseline of current local emissions to measure future progress against.

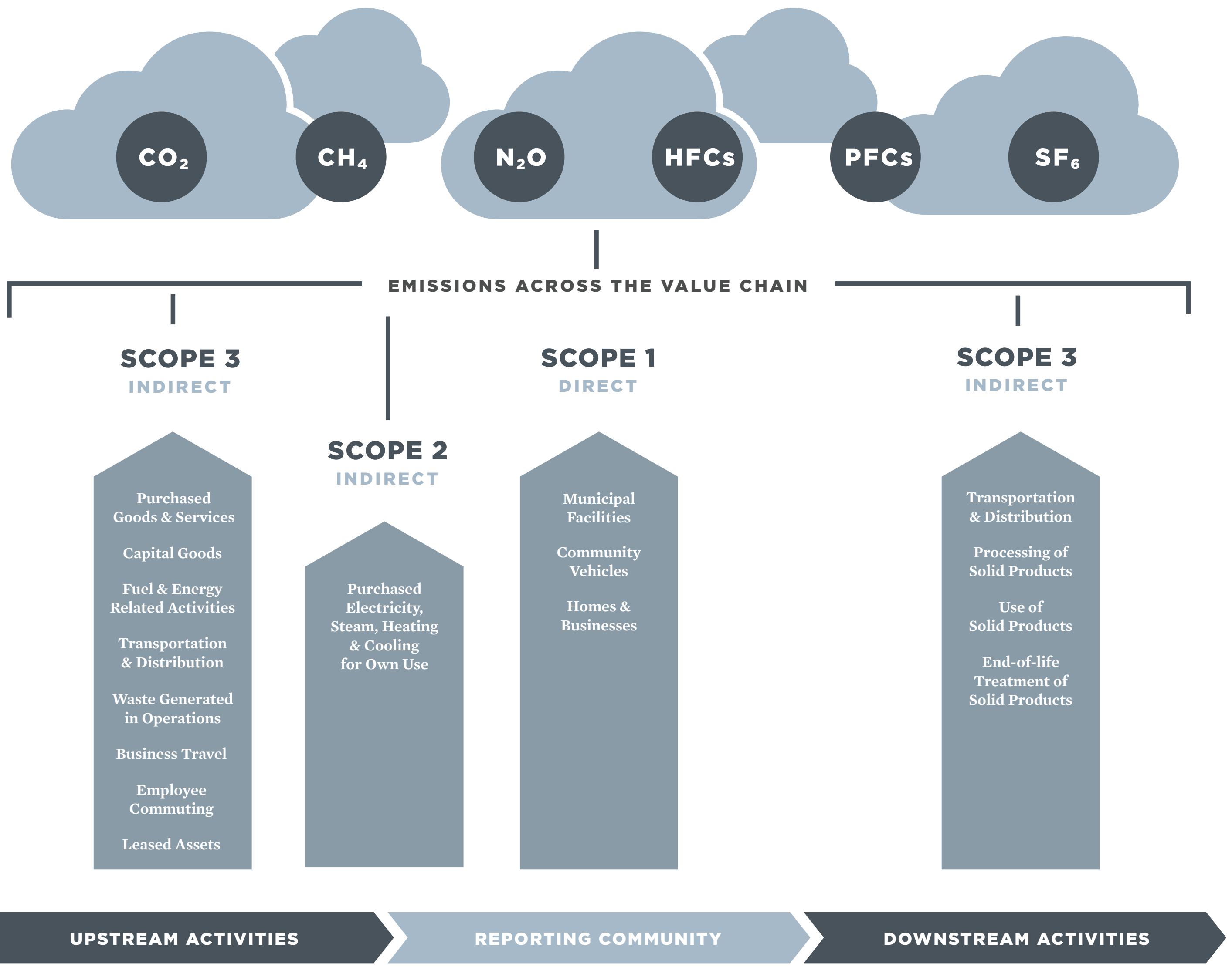
The standard approach to conducting a community GHG emissions inventory is to measure what are called “Scope 1” emissions, or those GHG emissions that are produced within the geographic boundary of the community. Forward-thinking communities are also conducting consumption-based inventories which measure what are called “Scope 3” emissions, or those GHG emissions that occur outside the communities geographic boundary as a result of goods and services purchased by households within the community (Figure 2).

But focusing solely on emissions sources without also taking into account the carbon sequestration and storage services of local natural resources is like attempting to balance a home budget from expenditures without considering revenues. Philipstown residents are surrounded by natural resources — forests, wetlands, fields, and farms — that work to sequester and store carbon from the atmosphere. If the ultimate goal is to create a carbon-neutral community, we must also measure the work these resources do to remove and store carbon from the atmosphere

FIGURE 2: THE SCOPES FRAMEWORK

The scopes framework for community-scale GHG emissions inventories accounts for emissions sources from within a community's boundary (Scope 1) and can support consumption-based accounting (Scope 3), but it does not account for natural carbon removals, such as from wetlands and forests.

OVERVIEW OF GHG PROTOCOL SCOPES AND EMISSIONS ACROSS THE VALUE CHAIN



"The innovative approaches used by this inventory reveal clearly how building strong local economies are vital to fighting climate change and underscores the vital role humans must play in becoming active caretakers of our natural resources."

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The goal of this report is to present a full picture of the Town of Philipstown's GHG emissions and sequestration and storage services. This innovative inventory looks at our community through three separate lenses:

1

A GEOGRAPHIC, OR PRODUCTION-BASED, INVENTORY

looks at emissions from human activities within the Town of Philipstown geographic boundary. Emissions in this inventory are primarily from use of fossil-fuel energy used in buildings and transportation. This is considered the "standard" approach most communities have used.

2

A HOUSEHOLD CONSUMPTION INVENTORY

looks at indirect (i.e., upstream) emissions associated with producing each good or service purchased by households in the Town of Philipstown. In addition to energy use and transportation by households, the consumption based inventory reveals significant emissions associated with food, with manufacturing of vehicles, construction materials, clothing and other goods, and with services such as health care, education, and entertainment. We believe that making emissions visible that result from local consumption decisions underscore why efforts to protect and rebuild local economies are essential in the fight to avert the worst impacts of climate change.

3

A LAND USE-BASED INVENTORY

looks at GHG emissions, removals (i.e., sequestration or sinking potential), and carbon storage (i.e., sink) from land use and land use changes in the Town. While many necessary actions to significantly limit emissions are beyond local control — such as putting a price on carbon or ratifying international climate agreements — decision-making over land use is firmly within the control of local communities and individuals. Expanding the climate change conversation to include actions people and communities can take to protect and increase the carbon sequestration and storage services of their surrounding ecosystem is ultimately empowering and underscores the vital role humans must play in becoming active caretakers of our natural resources.

PHILIPSTOWN INVENTORY REPORT | 2020 | GHG EMISSIONS INVENTORY

This inventory uses the approach and methods provided by the US Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (US Community Protocol), originally released by ICLEI in July 2013 with an updated Version 1.2 released in 2019, and represents the national standard in guidance to help US local governments develop effective community GHG emissions inventories. Until recently, methods for conducting carbon sequestration and storage inventories of land-uses have not been standardized. The Forest Land and Trees Appendix (Appendix J) to the US Community Protocol, released by ICLEI in September 2019, has moved the field forward and our collaboration has positioned the Town of Philipstown as a national leader in applying these updated inventory methods.

Finally, efforts have been made to align sectors and methodology with those used in New York State Energy Research and Development Authority's (NYSERDA) 2012 *Mid-Hudson Regional Greenhouse Gas Emissions Inventory* (Mid-Hudson GHG Inventory).[3] Those instances are noted in the Methods section.

[3] ICF International. (2012). Mid-Hudson regional greenhouse gas emissions inventory: Final report for Mid-Hudson Tier II Regional greenhouse gas emissions inventory. Retrieved from: https://www.dec.ny.gov/docs/administration_pdf/midhudghginventory.pdf

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Methods

ONLINE ACCOUNTING TOOLS

ICLEI's ClearPath online accounting tool (http://icleiusa.org/clearpath/) allows communities to create inventories of GHG emissions, forecast emissions change over time, and plan climate actions. Since its release as a cloud-based tool structured to facilitate protocol-compliant GHG inventories, more than 600 city, town and county staff have used ClearPath to create nearly 40,000 GHG inventory records and 200 climate planning scenarios. Philipstown's GHG inventory utilized this tool for completing all production-based accounting and to inform the consumption-based accounting efforts. We referred to the Berkeley CoolClimate Calculator Tool (https://coolclimate.berkeley.edu/calculator) for more in-depth guidance in completing the consumption-based accounting.

SECTORS

The *US Community Protocol* recommends measuring emissions from the following sectors in production-based accounting:

- Transportation and mobile sources, including on- and off-road transportation, aviation travel, public transit emissions, rail transportation, and water transportation;
- Stationary fuel combustion, including residential, commercial, and industrial sources of fuel oil, propane, kerosene, wood, etc.;
- Electricity use for residential, commercial, and industrial sectors;
- Solid waste generation, collection, transport, combustion, processing, and composting;
- Water and wastewater, including wastewater-treatment processes, septic system emissions, and effluent discharge;
- Agricultural, including enteric fermentation of livestock, fertilizer use, and manure treatment and handling;
- Land use changes, from forested-to-other-use or from other-use-to-forested;
- Process & fugitive emissions, including refrigerants and ozone-depleting substances and natural gas infrastructure leakage; and
- Electric grid loss, including emissions from transmission and distribution for both residential and commercial.

Additionally, the following sectors were measured for consumption-based accounting:

- Food consumption, including meat, dairy, produce, grains, and other;
- Other goods consumed, including wood and concrete construction materials, clothing, furniture, appliances and other goods; and
- Services consumed, including education, healthcare, entertainment, recreation and other services.

Finally, the following land use areas were measured in order to calculate carbon storage and removal (i.e., sequestration) in Philipstown:

- Forested acreage, including mixed forest, deciduous, and evergreen;
- Wetland acreage, including estuarine and marine deepwater, emergent herbaceous wetlands (i.e. marshes), freshwater emergent wetlands, woody wetlands, ponds and lakes;
- Grassland acreage, including pasture, hay and developed open space (i.e., lawns, golf courses, parks);
- Cropland acreage, including annual and perennial crops; and
- Developed impervious space acreage, including buildings, driveways, roads.

We utilized ICLEI's ClearPath tool to input all production-based (i.e., direct emissions and Scope 2 emissions) data. However, wanting to recognize both direct and indirect emissions (i.e., Scopes 1, 2 and 3), as well as the carbon storing and sequestering potential in our Town's natural resources, we also included two innovative methods:

- Conducting a Town-wide household survey to collect local consumption data. The Town of Philipstown is among the first municipalities to attempt to conduct a consumption inventory using locally-collected data, as opposed to relying on state or national-level estimates that are scaled-down; and
- Conducting a land use inventory in order to assign carbon storage and sequestration estimates to each land use category, including on-the-ground (in-the-muck) data collection in some of our local wetlands and creating a searchable land use map.

We provide comprehensive descriptions of all data sources, data collection and calculation methods by sector for our three inventory sections — production, consumption and land use — **in Appendix A: Complete methodology for the Town of Philipstown GHG baseline inventory.** We include such detail so that other municipalities and communities can utilize or improve upon our methods. Further data and calculations are available from the authors upon request.

Results

With this report, the Town of Philipstown takes a leadership role in the state of practice for greenhouse gas emissions inventories. The inventory's three-lense approach — looking at emissions using production-based, consumption-based, and land-based methods — attempts a fuller picture of climate-influencing activities in the Town and, in the process, showcases the strengths and weaknesses of each approach. In the end, the inventory also shows how these lenses complement one another to create a more robust, policy-relevant inventory useful to Philipstown planners, leaders, and residents alike as they develop a data-driven road-map to carbon neutrality.

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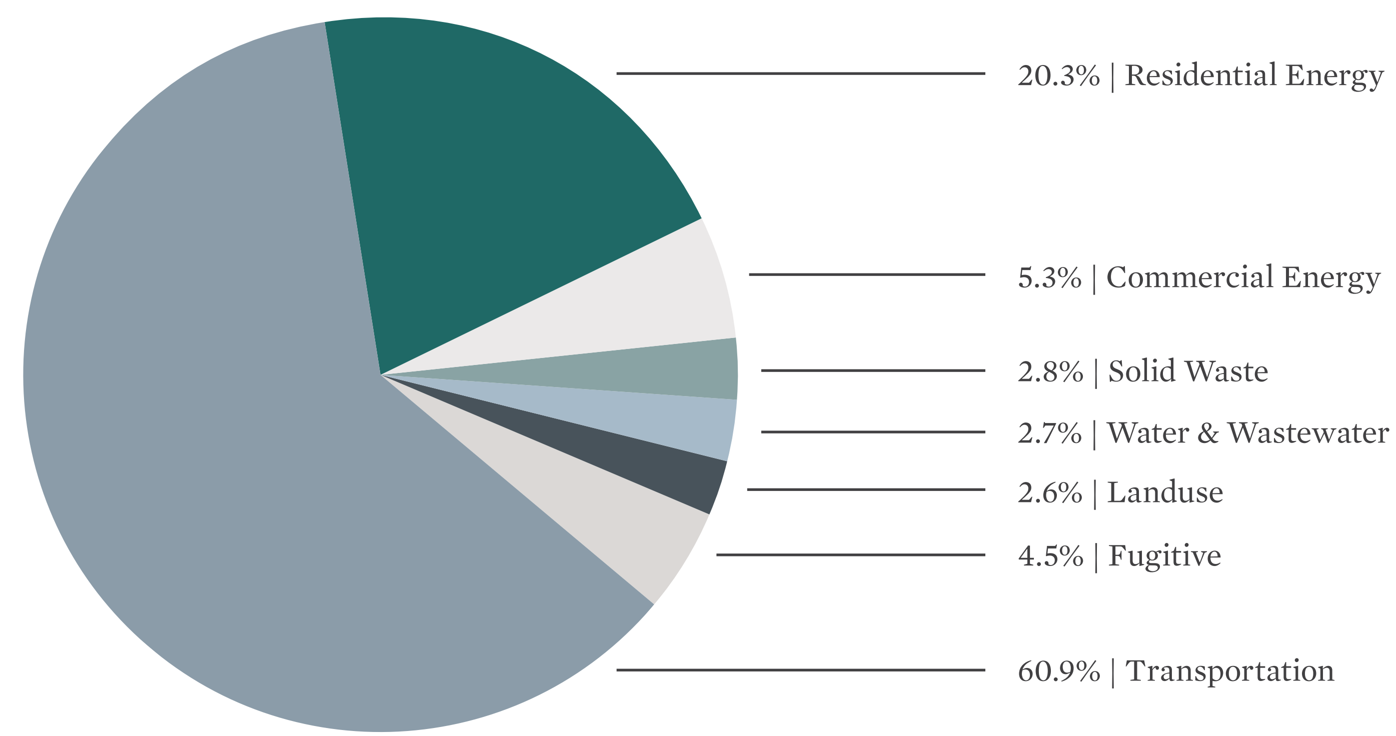
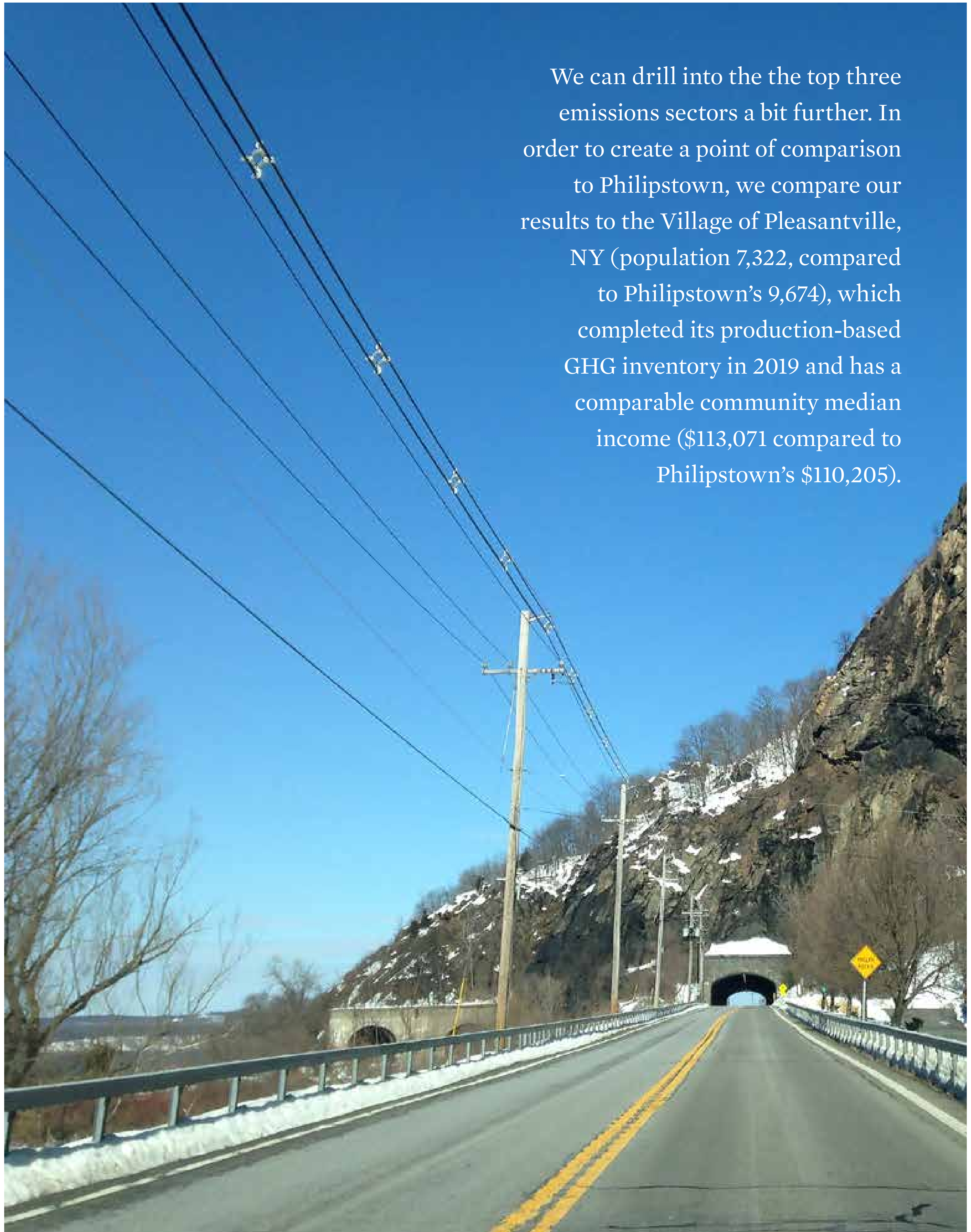
RESULTS: PRODUCTION-BASED GHG INVENTORY

The production-based approach is sometimes referred to as a geographic approach, because the boundary of the inventory coincides with the official jurisdictional boundary for the Town, capturing sources (but not sinks) of carbon emissions in Philipstown. The most recent, complete dataset was for the year 2016. Total emissions for the 2016 production-based inventory were calculated at 108,409 MTCO2e, or 30.4 MTCO2e per household and 11.1 MTCO2e per person (Table 1).

On-road transportation from both gasoline and diesel passenger and freight vehicles is the largest contributor to emissions, accounting for 42.6% of the total (45,805 MTCO2e), followed by heating fuels for homes and businesses with 16.5% of the total (16,796 MTCO2e). Rail transport accounts for the third-highest proportion of emissions at 11.2% (12,106 MTCO2e). The remaining sectors, including electricity and other fuels such as propane and kerosene, solid waste, water and wastewater, and fugitive emissions, contributed, but with significantly less input than for the top three sources (Table 1). Figure 3 displays our Town's emissions.

FIGURE 3. PHILIPSTOWN PRODUCTION-BASED GHG INVENTORY RESULTS (2016)





We can drill into the the top three emissions sectors a bit further. In order to create a point of comparison to Philipstown, we compare our results to the Village of Pleasantville, NY (population 7,322, compared to Philipstown's 9,674), which completed its production-based GHG inventory in 2019 and has a comparable community median income ($113,071 compared to Philipstown's $110,205).

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ON-ROAD TRANSPORTATION

On-road emissions include those from all vehicles that travel through Philipstown boundaries. This includes resident travel, as well as pass-through travel of non-residents. Total annual vehicle miles traveled are similar for both diesel and gasoline-fueled transport, roughly 102 million miles for each fuel type. Yet, the differences in each fuel's embedded carbon emissions becomes apparent with gasoline-fueled transportation accounting for six times the total emissions attributable to diesel fuels. For comparison, Pleasantville, NY, with a similar population, reports transportation-related emissions nearly in line with those of Philipstown (31 MTCO2e, compared to Philipstown's 39 MTCO2e).

HEATING FUELS

Of all electricity and other fuels used in homes and businesses, fuel oil contributes 65% of total emissions, underlying the necessity of switching to more sustainable heating sources. If one suspected wood heat to be a predominant source of home-heat emissions, they may be surprised to know wood accounts for only 2% of the residential sector's total, nearly identical to those from kerosene. As with transportation, Pleasantville's residential energy is nearly the same as Philipstown, while commercial energy emissions in Pleasantville are nearly three times those in Philipstown, pointing to the more urban characteristics of the municipality.

RAIL

With 10 miles of rail line running along the western border of Philipstown serving Amtrak and Metro-North trains, more than 1 million gallons of diesel fuel were estimated to have been used during 2002, the latest year for which data was available. Amtrak diesel train-miles during that year were 86,960 miles, while Metro-North rode 283,185 miles along the Hudson Line. These miles include resident travel within the boundary, but largely account for commuters and travelers passing through the town.

ELECTRICITY

Although a smaller portion of current carbon emissions in Philipstown, electricity is important both for its degree of influenceability — by way of energy efficiency measures and interaction with a fluctuating grid mix — and because of an anticipated future that may rely more heavily on electricity for charging electric vehicles, heating and cooking, and other processes.

TABLE 1: PHILIPSTOWN PRODUCTION-BASED COMMUNITY GHG INVENTORY (2016 DATA).

SECTOR	FUEL OR SOURCE	USAGE	USAGE UNIT	EMISSIONS (MTCO2e)	HOUSEHOLD EMISSIONS (MTCO2e / household)
Residential Energy	Electricity	38,401	MWh	5,178	1.4
	Heating Oil	1,365,570	Gallons	14,184	3.9
	Propane	273,658	Gallons	1,561	0.4
	Kerosene	51,029	Gallons	526	0.1
	Wood*	18,772	MMBtu	525	0.1
RESIDENTIAL ENERGY TOTAL				**21,974**	
Commercial Energy	Electricity	12,684	MWh	1,706	N/A
	Heating Oil	345,259	Gallons	3,577	N/A
	Propane	51,493	Gallons	294	N/A
	Kerosene	2,431	Gallons	25	N/A
	Wood*	5,559	MMBtu	155	N/A
COMMERCIAL ENERGY TOTAL				**5,757**	
On-Road Transportation	Gasoline	97,361,000	Vehicle Miles	39,500	11
	Diesel	4,800,800	Vehicle Miles	6,305	1.8
Rail	Diesel	1,170,027	Gallons	12,106	3.4
Water Transport	Diesel	N/A	N/A	4,510	1.3
Off-Road Vehicles	All Fuels	N/A	N/A	3,567	1
TRANSPORTATION TOTAL				**65,988**	

SECTOR	FUEL OR SOURCE	USAGE	USAGE UNIT	EMISSIONS (MTCO2e)	HOUSEHOLD EMISSIONS (MTCO2e / household)
SOLID WASTE	Waste combustion & collection	7,544	Tons Waste	2,955	0.8
	Composting	717	Tons Compost	72	0.02
SOLID WASTE TOTAL				**3,027**	
WATER AND WASTEWATER	Septic systems	7,724	People Served	2,849	0.8
	Central wastewater treatment processes, including effluent discharge and combustion of biosolids	1,971	People Served	45	0.01
WATER AND WASTEWATER TOTAL				**2,894**	
FUGITIVE	Refrigerant leakage	N/A	N/A	4,842	1.4
FUGITIVE TOTAL				**4,842**	
AGRICULTURE	Enteric fermentation of livestock	442	Acres	2,014	0.6
	Fertilizer	1,320	Acres	359	0.1
	Manure treatment and handling	442	Acres	446	0.1
AGRICULTURE, FORESTRY AND LAND USE TOTAL				**2,819**	
TOWN GOVERNMENT OPERATIONS**	Includes employee commute, electricity usage, fuel oil, gasoline and diesel	varies	Varies	694	N/A
TOWN GOVERNMENT OPERATIONS TOTAL				**694**	
UPSTREAM ELECTRICITY	Residential transmission and delivery	384,003,900	kWh Used	272	0.08
	Commercial transmission and delivery	12,648,340	kWh Used	89	N/A
UPSTREAM IMPACTS TOTAL				**361**	
COMMUNITY TOTAL EMISSIONS				**108,409**	**30.4**

**Wood emissions are in units CH4 and N2O produced from combustion and do not include biogenic CO2.*
*** The Town of Philipstown will publish a separate report detailing its government operations greenhouse gas emissions. See Appendix B for detailed results.*

RESULTS: CONSUMPTION-BASED GHG INVENTORY

While previous consumption-based inventories in other municipalities have based estimates on national or state-level data, this inventory is innovative in that it utilizes local data. Our researchers collected 261 valid household surveys in Philipstown, representing 7.2% of households in our Town (3,607 total households). We compared our sample statistics to the most recent American Community Survey statistics to assess the representativeness of our sample (Table 2). Our sample overrepresented persons who identify as female, persons 60 years or older, persons with a college education, and households with an income above $200,000. Thus, results must be interpreted with caution: persons under 40 years old, households with lower educational attainment, and households who have lower incomes are underrepresented in our sample.

TABLE 2. SAMPLE STATISTICS IN HOUSEHOLD SURVEY (N=261), COMPARED WITH 2016-2017 AMERICAN COMMUNITY SURVEY (ACS) DATA.

DEMOGRAPHIC		SAMPLE (n)	SAMPLE (%)	ACS (n)	ACS (%)
Number of Households		261	—	3,607	—
Persons per Household		2.6	—	2.6	—
Population		683	—	9,763	—
Gender	Female	153	58.6	4,834	49.5
	Male	98	37.6	4,929	50.5
	Prefer not to say	10	3.8	N/A	N/A
Age	<40 years	39	14.9	3,992	41.4
	40-49 years	56	21.5	1,717	17.8
	50-59 years	49	18.8	1,741	18.1
	60-69 years	70	26.8	1,232	12.8
	70+ years	42	16.1	980	10.1
	Prefer not to say	5	1.9	N/A	N/A
	Median age	—	—	45.5	—
Education	HS diploma or < HS	9	3.5	2,807	39.3
	Associates	11	4.2	598	8.4
	Bachelors	92	35.3	1,972	27.6
	Masters or higher	145	55.6	1,762	24.7
	Prefer not to say	4	1.5	N/A	N/A
Income	<$75,000	26	12.9	1,231	34.4
	$75,001-$100,000	24	11.9	365	10.2
	$100,001-$125,000	29	14.4	382	10.7
	$125,001-$150,000	27	13.4	381	10.6
	$150,001-$200,000	31	15.4	469	13.1
	>$200,000	64	31.8	752	21
	Prefer not to say	60	22.3	N/A	N/A
Median household income		$125,000-$150,000	---	$110,205	---
Race*	White	N/A	N/A	8,891	91
	Black / African American	N/A	N/A	197	2.1
	Asian	N/A	N/A	172	1.8
	Other race	N/A	N/A	504	5.2
Latinx origin*	Hispanic or Latinx	N/A	N/A	680	7
Tenancy	Owner	231	88.5	2,884	78.3
	Renter	30	11.5	801	21.7

Source: Sample data from the 2019 Philipstown Community Survey; Population estimates from the 2016-2017 American Community Survey.
** Race and ethnicity were not collected in the Philipstown Community Survey.*

Furthermore, our sample scored very high on a scale to assess climate change attitudes. (e.g., “I am concerned about global climate change,” “Human activities cause climate change,” “The actions of individuals can make a positive difference in global climate change.”) The maximum score on the scale was 32, with a higher score indicating high awareness or concern for climate change. Over 70% (72.8%) of survey respondents scored 30-32; 13.8% scored in the 27-29 range; 7.7% scored in the 24-26 range; and only 5.8% scored less than 24. This suggests a bias in our sample: Household respondents are already concerned with anthropogenic (or human-made) effects on our environment and believe that anthropogenic actions can mitigate the effects.

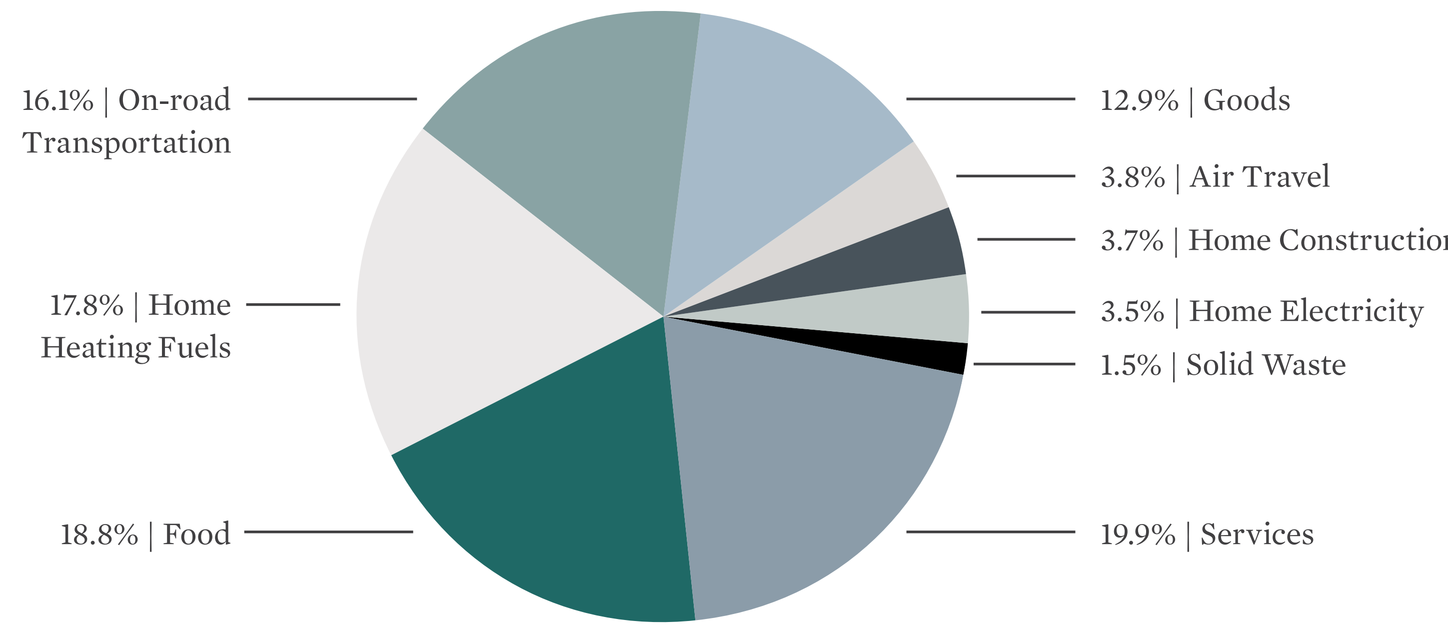
According to our community survey results, total emissions were estimated to be 198,703 MTC02e for the community as a whole, which translates to 55.5 MTC02e per household or 20.4 MTCO2e per person (Table 3). The largest contributors to household consumption emissions in Philipstown are services with 39,553 MTCO2e (11.0 MTCO2e per household). These are followed by food consumption with 37,322 MTCO2 (10.4 MCO2e per household), home heating with 35,332 MTCO2e (9.8 MTCO2e per household), car travel with 32,048 MTCO2e (9.0 MTCO2e per household), goods consumption with 25,644 MTCO2 (6.5 MTCO2e per household), air travel with 7,567 MTCO2e (2.1 MTCO2e per household), home construction with 7,295 MTCO2e (2.0 MCO2e per household), non-heating electricity use with 6,879 MTCO2e (1.9 MTCO2e per household), solid waste, water and wastewater with 5,921 MTCO2e (1.7 MTCO2e per household) and rail travel with 1,140 MTCO2e (0.3 MTCO2e per household). See Figure 4.

TABLE 3. COMMUNITY & PER HOUSEHOLD EMISSIONS USING CONSUMPTION-BASED ACCOUNTING METHODS (2019)

SECTOR	COMMMUNITY MTCO2e	MTCO2e per HOUSEHOLD	%
Services (includes healthcare, education, entertainment and other services)	39,553	11	19.9
Food	37,323	10.4	18.8
Home heating	35,332	9.8	17.8
Car travel	32,049	9	16.1
Other goods consumption (includes clothing, appliances, furniture and other goods)	25,644	7.2	12.9
Air travel	7,567	2.1	3.8
Home construction	7,295	2	3.7
Non-heating electricity use	6,879	1.9	3.5
Solid waste, water and wastewater	5,921	1.7	3.0
Rail travel	1,140	0.3	0.6
Totals	198,703	55.5	100

Source: Philipstown Community Survey, 2019.

FIGURE 4. PHILIPSTOWN CONSUMPTION-BASED GHG INVENTORY RESULTS (2019)



An important limitation of the household survey was that it did not include questions on services consumption. Relevant services to include would have been health care, education, information and communication, medical, vehicle service, personal business and finance, household repair, organizations and charity and other services. Therefore, estimates of emissions for services - which is the sector with the highest emissions estimates, representing 19.9% of total consumption emissions - were calculated using median income as a proxy for household consumption. While these estimates may be representative of true service consumption behavior, we do not have locally collected data for comparison.

Philipstown’s total emissions estimates of 55.5 MTCO2e per household from our consumption-based GHG inventory are similar to Croton-on-Hudson, NY at 52.6 MTCO2e per household,[4] and King County, WA,[5] at 50.3 MTCO2e per household. It should be noted that the methodologies used for those consumption-based inventories were different. Most notably, neither used a survey to collect local consumption data; rather, each community relied on data from national consumption surveys adjusted with local demographic data.

The household survey collected additional data that were not used in calculating emissions, but are helpful in understanding local consumption patterns (Table 4). For example, we asked households to identify where they buy the majority of a particular good, including food, personal care products, cleaning products, household or home improvement products and gifts. On average, about a quarter (28.9%) of overall household goods were purchased from within Philipstown. However, a significant portion of food, personal care products, household cleaning products and home improvement products are purchased outside of Philipstown, at big box or chain stores and a majority (50.5%) of gifts for others are purchased online.

[4] Croton100. Croton 100 Master Plan (2019). Retrieved from http://croton100.org
[5] Cascadia Consulting Group. King County greenhouse gas emissions inventory: A 2015 update. (2017). Retrieved from: https://your.kingcounty.gov/dnrp/climate/documents/2015-KC-GHG-inventory.pdf

TABLE 4. POINTS OF PURCHASE FOR VARIOUS HOUSEHOLD GOODS IN PHILIPSTOWN (N=261 HOUSEHOLDS).

HOUSEHOLD GOOD	WITHIN PHILIPSTOWN (%)	OUTSIDE OF PHILIPSTOWN, SMALL OR LOCALLY-OWNED STORES	BIG BOX, CHAIN STORES	ONLINE	OTHER
Food	39.5	17.2	41.4	0.77	1.1
Personal care products	23.8	7.7	51.7	16.1	0.77
Household cleaning products	26.8	6.5	55.6	10.3	0.77
Household home improvement products	18.0	6.5	72.0	2.7	0.77
Gifts for others	36.4	5.7	5.7	50.5	1.5

Source: Philipstown Community Survey, 2019.

In addition, we asked households to identify where they buy the majority of their food (Table 5) — a key piece to understanding how we might reduce emissions in this sector, which represents 18.8% of consumption emissions. The majority of households consume food that is purchased in a supermarket, representing the more GHG-intensive food source. Alternatively, some households purchase their foods from local stores that sell locally-produced products, farmers markets, or direct from a local farm. Consumption from such outlets has on average lower GHG emissions, especially if organic growing practices are used by the producers.

TABLE 5. PERCENT OF HOUSEHOLDS FOR WHICH EACH OUTLET IS PRIMARY SOURCE FOR FOOD PURCHASING, BY TYPE OF FOOD (N=261 HOUSEHOLDS).

OUTLET	MEAT	DAIRY	VEGETABLES	SNACK FOODS
Supermarket	60	80	50	79
Local store, locally produced	21	12	21	6
Farmers market, farm or CSA	9	3	2	0
Other or don't buy	10	6	5	15

Source: Philipstown Community Survey, 2019.

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Nearly one-tenth (9.81%) of persons represented in the household survey identify as vegetarian and 2.8% as vegan. A majority of households (67.4%) report wasting less than 10% of their food, which is in sharp contrast to the national average of 40% of food being wasted. Relatedly, nearly half of respondents (47.1%) report composting their food waste, a regenerative practice that sequesters carbon in soil organic matter, and nearly two thirds (62.8%) report recycling more than 40% of their household waste.

Households were also asked to report on their property management or landscaping behaviors. Nearly 70% (69.7%) reported using gas-powered landscaping tools. Nearly half (48.6%) reported using organic fertilizers or pesticides for management purposes; 12.6% indicated they use inorganic fertilizers or pesticides, and 13.4% indicated that they didn't know what types of fertilizers or pesticides were applied.

CHRISTINE ASHBURN PHOTOGRAPHY

RESULTS: COMPARING EMISSIONS FROM PRODUCTION-BASED ACCOUNTING VERSUS CONSUMPTION-BASED ACCOUNTING

Conducting both production-based and consumption-based inventories in the Town of Philipstown from real local data reveals important differences about how we view the GHG emissions we are responsible for as a community. The production-based inventory, which only measures emissions produced within the Town of Philipstown's geographic boundary, estimates community-wide emissions of 108,409 MTC02e and 30.4 MTC02e per household.[6] The consumption-based inventory, which measures elements of emissions produced within the Town of Philipstown's geographic boundary but also incorporates indirect (i.e upstream) emissions from the goods and services we purchase as a community, estimates community-wide emissions of 198,703 MTC02e and 55.5 MTC02e per household (compared to 50 MTC02e per the average US household). Philipstown's consumption-based inventory estimates total emissions that are 84% greater than our production-based inventory estimates. See Table 6 for a direct comparison of the production-based and comparison-based inventories.

From a global perspective, we would expect total consumption-based and production-based emissions to be equal because what is consumed in one community is produced in another. Because emissions-intensive industries, such as steel production and petroleum refining tend to be concentrated in a few communities, or located outside the US, most US communities have a higher consumption-based than production-based footprint. A study of 79 large cities around the world found that 80% had consumption-based emissions larger than their production-based emissions, and a majority had consumption-based emissions at least twice their production-based emissions.[7] Thus it is not surprising that Philipstown, as an affluent community with no industry, has consumption-based emissions nearly twice its production-based emissions.

We recommend using the consumption-based inventory estimates to set the emissions baseline for the Town of Philipstown, primarily because it most accurately captures the emissions that result from the actions of individual members of our community (which we have control over) while leaving out emissions that we aren't responsible for (such as emissions produced as non-community members drive or take the train through our geographic boundary). Philipstown's consumption-based inventory estimates reveals how much of the emissions picture a standard production-based inventory can miss and how important individual consumption decisions are to addressing global climate change. Recent studies have shown that direct and indirect emissions related to household consumption decisions are responsible for nearly 80% of America's total emissions.[8] Emissions produced as a result of a household's consumption decisions generally increase with household income, with America's wealthiest households responsible for five times more emissions than the poorest households.[9]

[6] Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

[7] C40 Cities. Consumption-based GHG emissions of C40 cities. (2018). Retrieved from: https://www.c40.org/researches/consumption-based-emissions

[8] Song, K., Qu, S., Taiebat, M. et al. (2019). Scale, distribution and variations of global greenhouse gas emissions driven by US households. Environment International, 133(A). doi:10.1016/j.envint.2019.105137

[9] Song, K., Qu, S., Taiebat, M. et al. (2019). Scale, distribution and variations of global greenhouse gas emissions driven by US households. Environment International, 133(A). doi:10.1016/j.envint.2019.105137

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To avoid double-counting emissions, not all production-based sectors are carried over explicitly into the consumption-based inventory, but rather are accounted for in consumption-based calculations. For example, commercial heating and commercial electricity are included under services and goods. Most off-road vehicles would be assigned to home construction, to foods and services (if used for commercial building construction), or to services if the vehicle is used by a business to provide a service such as landscaping. Fuel use in off-road vehicles operated directly by residents would not be included in the consumption based inventory. Water transportation is considered freight transportation, which is accounted for in the food, goods and services emissions factors. Agricultural and livestock emissions show up under food. Refrigerant leakage from commercial and industrial sources is included as part of goods and services.

The top five emission categories (services, food, home heating, on-road transportation, and goods consumed) are responsible for 85.5% of the Town of Philipstown's community-wide emissions. We will discuss the implications of these emissions estimates for each category separately, with the hopes that these findings help guide the Town of Philipstown's Climate Smart Community task force as they develop the community's CAP in the months ahead.

CHRISTINE ASHBURN PHOTOGRAPHY

TABLE 6. COMPARISON OF PRODUCTION-BASED TO CONSUMPTION-BASED EMISSIONS, BY SECTOR.

SECTOR	PRODUCTION-BASED		CONSUMPTION-BASED	
	Community	MTCO2e/ household	Community MTCO2e	MTCO2e/ household
Services	-	-	39,553	11.0
Food	-	-	37,322	10.4
Home heating fuels	16,796	4.7	35,332	9.9
On-road transportation	45,805	12.8	32,048	9.0
Goods	-	-	25,644	7.2
Air travel	-	-	7,567	2.1
Home construction	-	-	7,295	2.0
Home electricity	5,178	1.5	6,879	1.9
Refrigerant leakage	4,842	1.4	-	-
Water transportation	4,510	1.3	-	-
Commercial heating	3,871	1.1	-	-
Off-road vehicles	3,567	1.0	-	-
Solid waste	3,027	0.9	3,027	0.9
Water and wastewater	2,894	0.8	2,894	0.8
Rail	12,106	3.4	1,140	0.3
Agriculture livestock practices	2,818	0.8	-	-
Commercial electricity	1,706	0.5	-	-
Government operations	694	-	-	-
Grid loss and T&D	595	0.2	-	-
Total	108,409	30.4	198,701	55.5

RESULTS: PHILIPSTOWN LAND USE INVENTORY

Philipstown's area is roughly 33,000 acres, of which 79.9% is forested, 7.4% is developed open space (i.e., lawns and golf courses), 2.8% is developed impervious (i.e., buildings, roads, driveways), 2.4% open water (Hudson River and streams), 2.3% woody wetlands, with the remaining land use types occupying less than 2% of Town land each (Table 7).

The acreages for forests, developed open space (which includes lawns, turf, golf courses, parks), wetlands, grasslands (which includes pasture and hay, both managed and unmanaged) and cultivated crops were used to estimate carbon sequestration by multiplying the land category's total area by the respective carbon multiplier. For wetlands, we also used probing sampling depths collected by Philipstown volunteers (Appendix C) and total wetland acreage to estimate carbon stored. Carbon sequestration is the removal of carbon from the atmosphere per year through the process of photosynthesis. Carbon storage is the total amount of carbon bound up in above ground biomass and below ground as a result of past sequestration.

We created a searchable PDF map of different Philipstown land uses that is available by request from the authors. This searchable map allows one to identify each land use category, and in addition, to determine if particular high-value sequestering and storing land uses are located on tax-parcels that are currently protected or conserved through local, state or national protection programs. We hope this map proves useful in helping the community identify high priority resources for future protection. We included three map layers in this report for reference: Figure 5, which displays land use in Philipstown according to the 2016 NLCD, Figure 6, which displays public and private protected areas in the Town, and Figure 7, which displays all land cover/land use types by protected areas in the Town of Philipstown.

The methods for carbon sequestration estimating are described in detail in the Methods Appendix A. Our carbon multipliers and carbon sequestration estimates are reported in Table 7. Note that we report ranges for sequestration estimates due to high variability depending on local conditions.

TABLE 7. LAND COVER IN PHILIPSTOWN, BY LAND USE CATEGORY, AND ANNUAL CARBON SEQUESTRATION ESTIMATES (2016).

LAND USE CATEGORY[1]	TOTAL ACRES IN PHILIPSTOWN	% OF PHILIPSTOWN LAND COVER	CARBON MULTIPLIER (g CO2e/m^2/yr)	C-SEQUESTERED ESTIMATE (MTCO2e/year)
Forest (deciduous, evergreen and mixed)*	26,184	79.9	696.7[2]	73,829
Developed, open space (i.e., lawns, parks, golf courses)*	2,437[3]	7.4	93.1-749.1[4]	1,786-5,470
Developed, impervious (i.e., buildings, roads, driveways)*	919	2.8	0	0
Open water (Hudson River and streams)	787	2.4	-75.5[5]	-241
Woody wetlands**	744	2.2	696.7[6]	2,098
Ponds/lakes**	544	1.6	143-781[7]	315-1,719
Grasslands (pasture/ hay managed)*	517	1.6	295.5-671[4]	618-1,404
Estuarine/marine wetland (i.e., marsh)**	281	0.85	440-990[8]	500-1,126
Grasslands (pasture/ hay unmanaged)*	154	0.53	93.1-418.8[4]	58-261
Emergent herbaceous wetland**	119	0.36	143-781[6]	69-376
Barren land*	48	0.15	0	0
Cultivated crops***	19	0.06	44-733.3[9]	3-56
TOTALS	32,777 acres	99.9	---	79,036-86,098

NOTES:
[1] Land cover acreage estimates from the National Land Cover Database (*), the National Wetlands Inventory (**) and Cropscape (***).
[2] source: Schuster et al. (2008).
[3] Acerage estimated as 1,219 acres minimal input; 914 acres medium input; 305 acres best management practices.
[4] source: Zirkle et al. (2011).
[5] source: USGS Eastern US Carbon storage report (2014). Value is negative because it is an emission.
[6] source: US National Inventory and US Community Protocol, Appendix J, recommends treating woody wetlands as forest.
[7] source: State of the Carbon Cycle (2018).
[8] source: Craft C (2007); Craft C, Clough J, Ehman J, et al. (2009).
[8] source: USGS Eastern US Carbon storage report (2014).

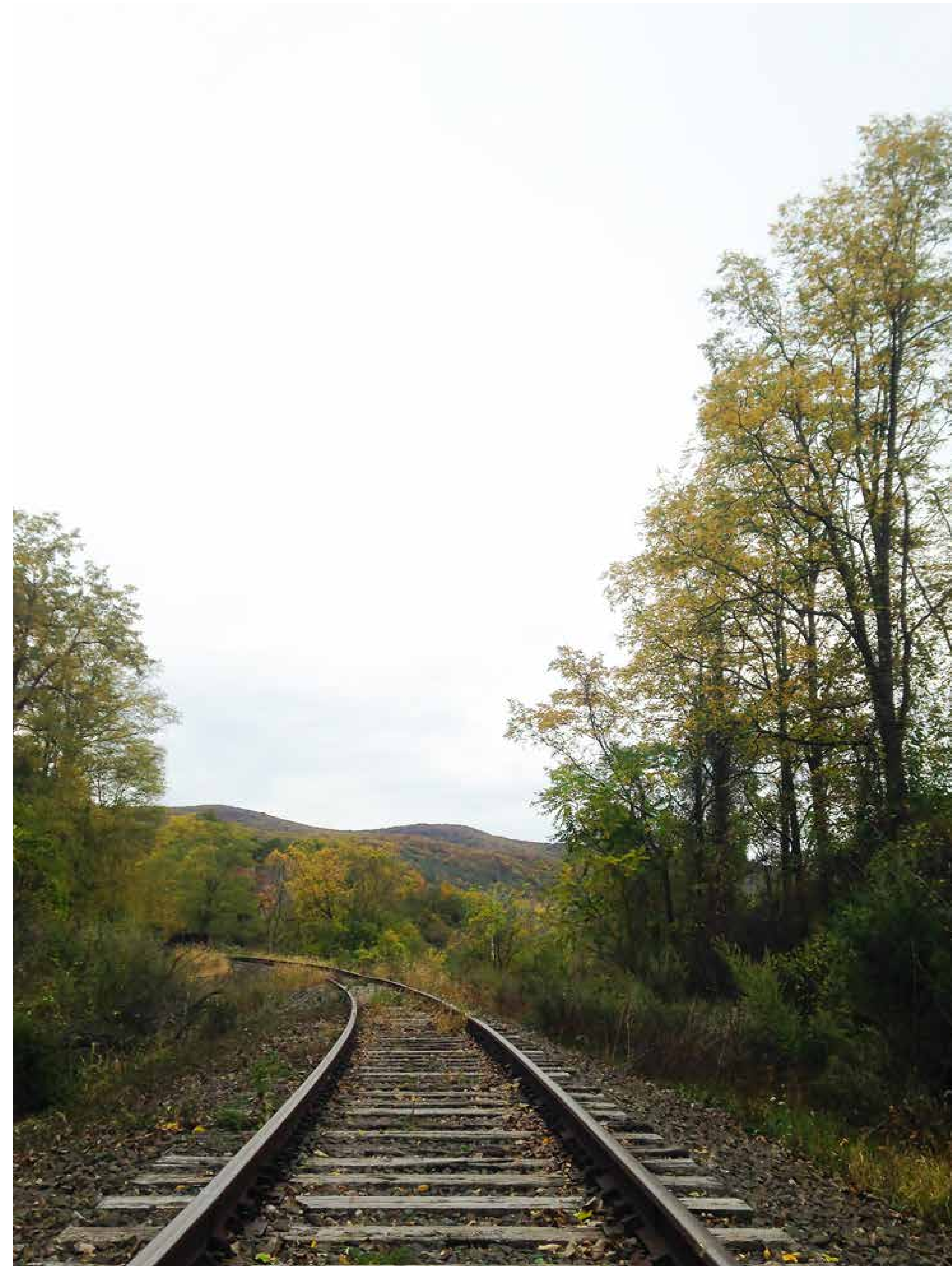

PHOTO CREDIT: LEIGH BAUMANN

FIGURE 5: TOWN OF PHILIPSTOWN'S LAND USE/LAND COVER, NLCD DATABASE (2016)

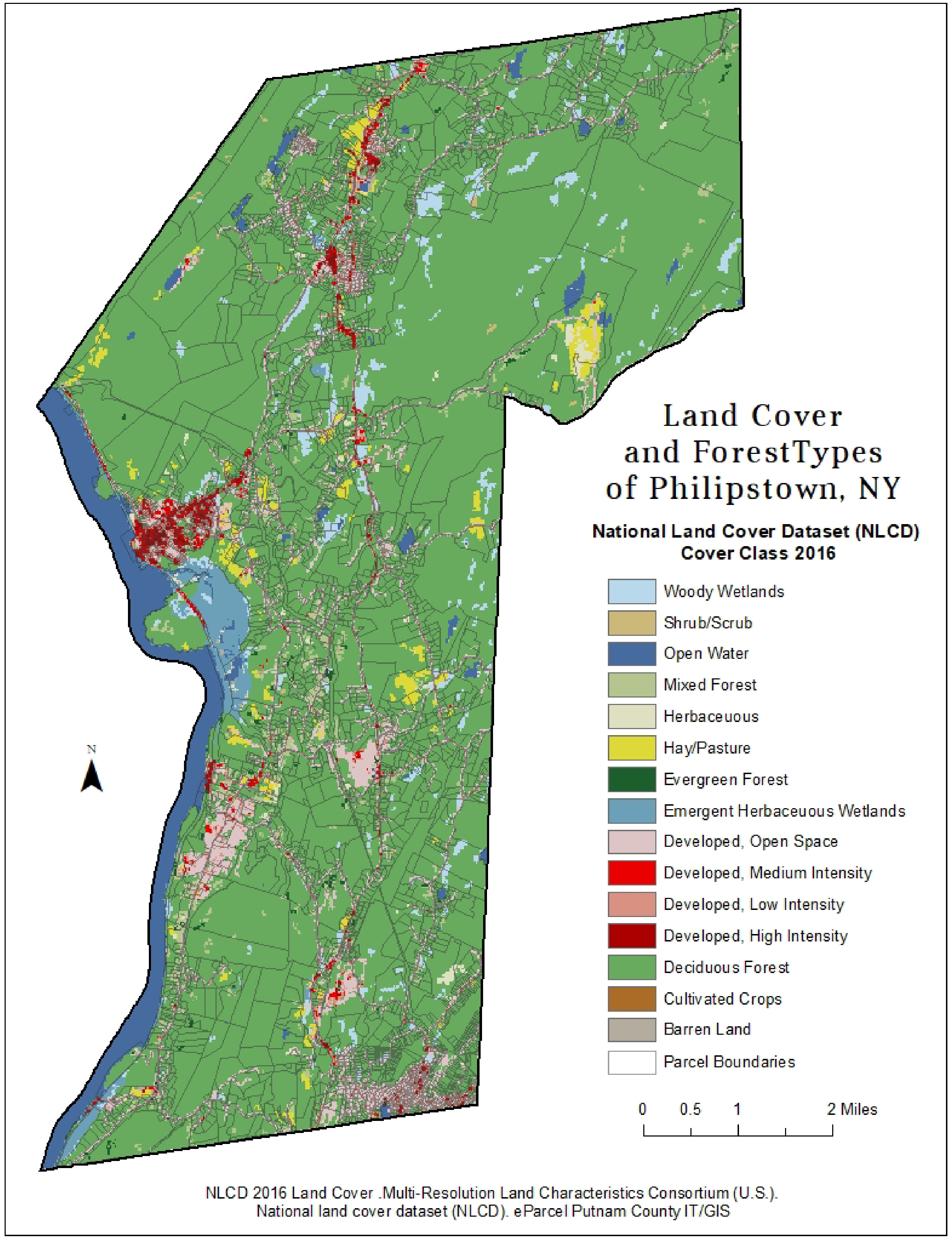

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FIGURE 6: PROTECTED AREAS, PUBLIC AND PRIVATE, IN TOWN OF PHILIPSTOWN (2019)

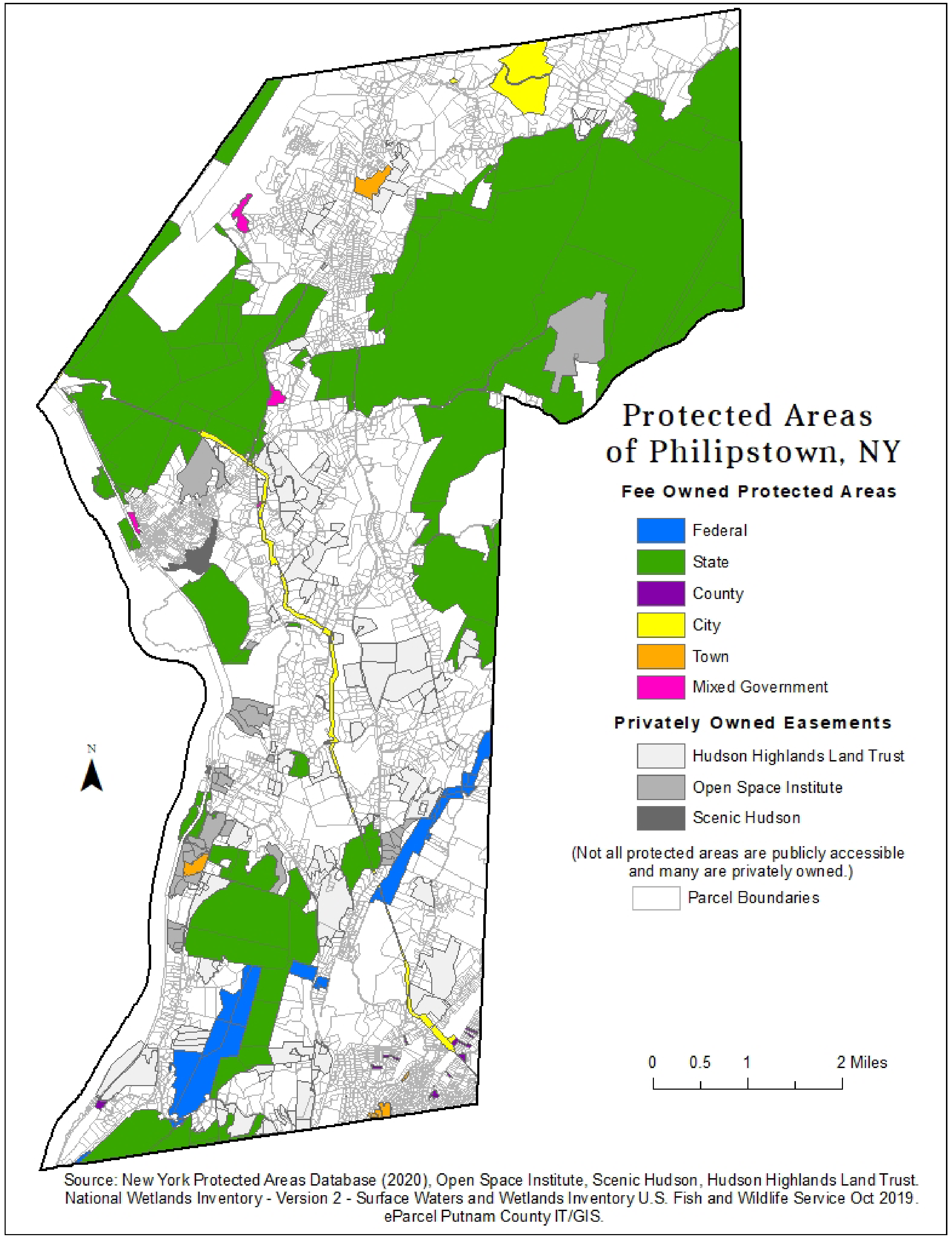
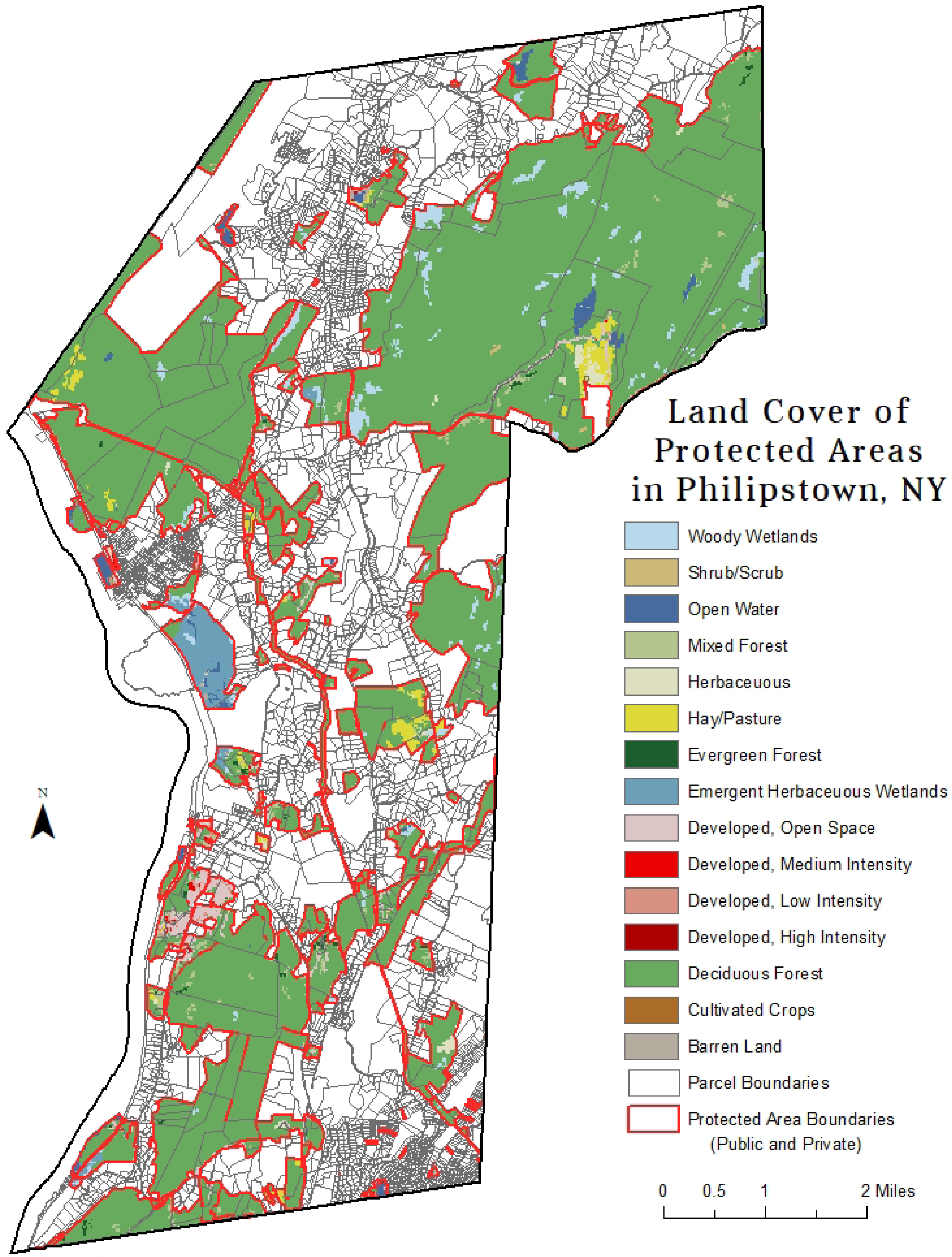


FIGURE 7: LAND COVER OF PROTECTED AREAS IN TOWN OF PHILIPSTOWN (2019)



Source: New York Protected Areas Database (2020), Open Space Institute, Scenic Hudson, Hudson Highlands Land Trust. NLCD 2016 Land Cover .Multi-Resolution Land Characteristics Consortium (U.S.). National land cover dataset (NLCD). Putnam County IT/GIS.

The estimated total amount of carbon sequestered by Philipstown land use is 79,036-86,0,628 MTCO2e per year (21,068-21,990 Mtons-C/year), with forests sequestering an estimated 73,829 MTCO2e per year (20,135 Mtons-C/year), or 86-96% of all carbon sequestered; followed by wetlands other than the open Hudson River sequestering an estimated 2,982-5,318 MTCO2e per year (813-1,450 Mtons-C/year); turf, lawns and developed open space sequestering an estimated 1,786-5,470 MTCO2e per year (487-1,492 Mtons-C/year), grasslands (managed and unmanaged pasture/hay) sequestering an estimated 676-1,665 MTCO2e per year (184-454 Mtons-C/year), and cultivated crops sequestering an estimated 3-56 MTCO2e per year (0.92-15.4 Mtons-C/year). Furthermore, the amount of carbon stored in our wetlands is an estimated 6,960,189 MTCO2e (1,898,233 Mtons-C).

The forests, wetlands, and fields of Philipstown sequester emissions equivalent to 40% of Philipstown's annual community-wide emissions. And even though wetlands comprise only 5% of Philipstown's land use, they store an amount of carbon that is equivalent to nearly twenty years of Philipstown's annual community-wide emissions. While it is up to the Town of Philipstown to determine if the sequestration and storage of carbon by Philipstown's land use, land use changes and forestry will be used to offset our annual emissions in CAP target-setting, these estimates highlight that the loss of land uses like forest, wetland, or fields would be a source of significant new emissions that make the path to local carbon neutrality difficult to achieve.

We also analyzed the change in land cover over time by comparing the 2001 and 2016 NLCD land cover types (Figure 8). Philipstown experienced a small amount of land cover conversion over this time period: just 0.017% (558.7 acres) of its total acreage, the majority of this in changes in open water land use (Table 8). The NLCD change database does not indicate what land was converted from, making it difficult to determine if there has been a net gain or loss in carbon storage potential. However, we were able to calculate the change in acreage for each land use category by comparing the 2001 and 2016 acreages for comparison (Table 9). This baseline can be used to compare with future land use changes in our Town.

LAND USE CATEGORY	TOTAL ACRES
Land use change	Acreage
Water change	261.8
Forest change	137
Urban change	99.4
Hay/pasture change	24.5
Wetland within class change	20.2
Herbaceous wetland change	14.9
Barren change	0.7
Cultivated crop change	0.2
Total acreage changed, 2001-2016.	558.7
% of Philipstown land changed, 2001 to 2016.	0.017

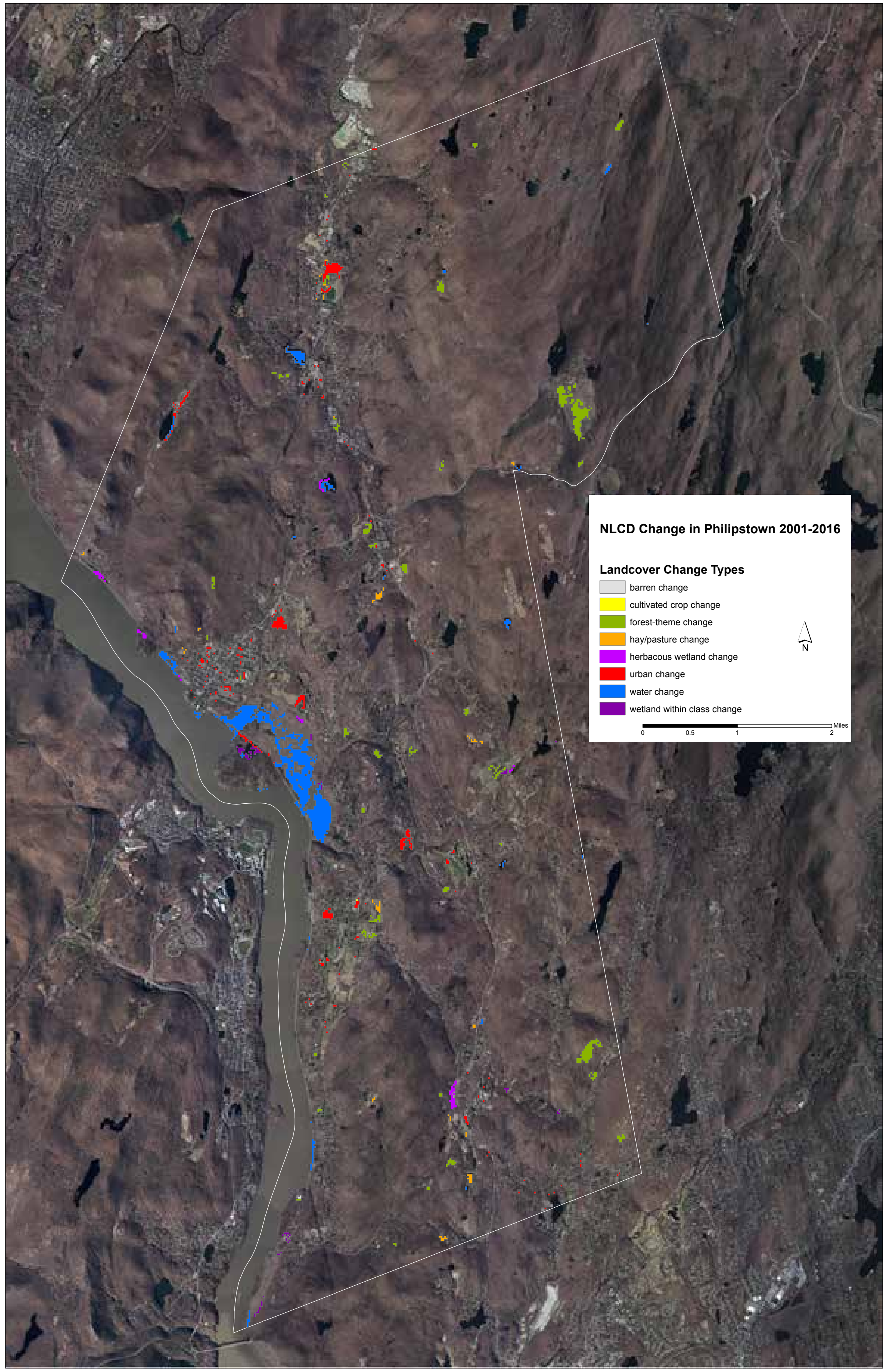
LEFT: TABLE 8. LAND USE CHANGES IN PHILIPSTOWN FROM 2001 TO 2016, AS CLASSIFIED BY THE NLCD LAND COVER CHANGE DATABASE.

BELOW: TABLE 9. CHANGE IN LAND USE CATEGORIES, CALCULATED FROM THE 2001 TO 2016 NLCD DATABASES.

LAND USE CATEGORY	2001 ACREAGE	2016 ACREAGE	CHANGE IN ACRES	CHANGE IN C SEQUESTRATION (MTCO2e /year)
Forest (deciduous, evergreen, mixed)	26,173	26,184	11.5	32.4
Developed, open space (i.e., lawns, parks, golf courses)	2,409	2,437	27.5	10-83
Developed, impervious (i.e., buildings, roads, driveways)	858	919	61.3	N/A
Open water (Hudson River and streams, including ponds/lakes and estuarine wetlands)	1749	1612	-137.4	--- *
Woody wetlands	792	812	20	56
Grasslands (pasture/hay managed)	528	517	-11.6	(-13) - (-31)
Grasslands (unmanaged)	66	178	112	42-190
Emergent herbaceous wetland	429	510	80.7	47-255
Barren land	33	48	15.4	N/A
Cultivated crops	0	19	19	3-56
Totals	33,037	32,777	198.7	159.4-659.4

** The NLCD databases do not differentiate between open water, ponds, lakes, estuarine wetlands.*

FIGURE 8. LAND USE CHANGE IN PHILIPSTOWN, 2001 TO 2016 (NLCD)



Implications for Philipstown

This report includes an inventory of community-wide GHG emissions, which is a requirement of participating in New York's Climate Smart Community program.

This inventory and report are intended to help the Town of Philipstown develop a Climate Action Plan (CAP): a set of steps and recommendations that our Town and the households within it can take to reduce their emissions, maximize carbon sequestration, and set targets to reach carbon neutrality.

Based on our reported results and discussions with dozens of local stakeholders and scientists, we lay out implications for the Town of Philipstown by sector below. For comparison, we refer to consumption-based emissions for the average US household when applicable (Figure 9). None of the recommendations included in this section of the report have been officially endorsed by the Town of Philipstown, but were developed by the authors of this report to help in the development of a CAP that can serve to make our town a national local leader in the fight against climate change.

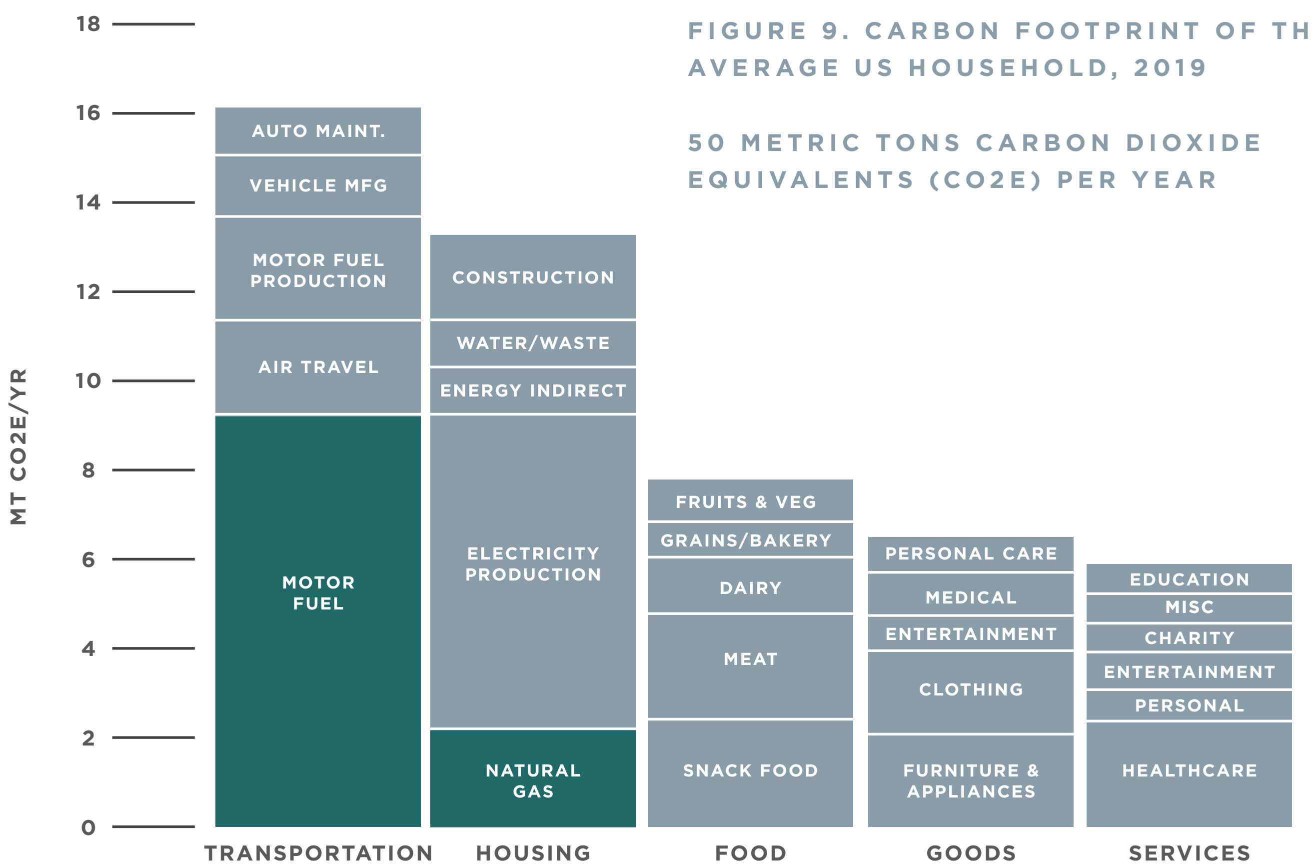
IMPLICATIONS: SERVICES

This consumption-based inventory estimates that emissions associated with services purchased by community members is the leading source of local emissions (39,553 MTC02e and 11.0 MTC02e per household). Purchased services account for 21% of Philipstown's community-wide emissions, compared to approximately 12% of emissions that result from the purchase of services by the average of US households.[10] While the average American purchases incrementally more services than goods each year,[11] relatively high incomes in Philipstown ($110,205 per year versus the New York state average of $65,323) mean a higher consumption of services which result in large overall emissions from services. Given that we had no local data on the consumption of services, this emissions calculation is based on national average emissions intensity.

Estimates of primary services purchased include healthcare, education, financial services and entertainment, with secondary services including vehicle repair, household maintenance and repair, education, healthcare, personal business and finances, entertainment and recreation, information and communication, and charitable giving. Based on recent studies analyzing the GHG emissions intensity of different services purchased by American households, healthcare services alone produce the most domestic emissions (7.0%), followed by entertainment (2.8%) and education (2.3%).[12]

FIGURE 9. CARBON FOOTPRINT OF THE AVERAGE US HOUSEHOLD, 2019

50 METRIC TONS CARBON DIOXIDE EQUIVALENTS (CO2E) PER YEAR



Source: coolclimate.berkeley.edu

PHILIPSTOWN INVENTORY REPORT | 2020 | IMPLICATIONS

How does the purchase of services drive GHG emissions?

The United States spends the most of any nation by far on its health care system, nearly one-fifth of GDP, or approximately $3.6 trillion dollars in 2018 — or $11,172 per person,[13] with US health care activities responsible for 10% of national GHG emissions in 2013.[14] If the US health care sector were itself a country, it would rank 13th in the world for GHG emissions.[15] Emissions from health care services result from direct emissions from the construction and operation of health care facilities and vehicles and more significantly from the emissions associated with the production of electricity, drugs, medical devices and supplies that feed into the health care sector. In 2013, the largest contributors to the total emissions of health care services were hospital care (36%), physician and clinical services (12%), medical structures and equipment (11%), and prescription drugs (10%).[16]

Entertainment services are most often the recreational activities we choose to engage in with our leisure time, such as watching television, being on-line, reading, socializing or exercising. From an environmental perspective, how we choose to entertain ourselves has very different GHG emission ramifications. Powering digital devices like computers, smartphones, televisions and broadcast infrastructure consumes roughly 9% of global electricity use.[17] US data centers — which contain the servers which support emailing, streaming, and on-line search platforms — represent 2% of US total energy consumption.[18] Other entertainment activities, like reading, socializing, or exercising outdoors have far less environmental impacts.

Educational services such as attending schools, colleges or universities are associated with significant GHG emissions. In 2005, US higher education institutions accounted for 2% of total US GHG emissions, almost entirely due to purchased electricity, building heating and cooling, and commuting.[19] These same activities also drive GHG emissions at primary and secondary schools.

As we consider how to reduce local emissions resulting from services, we should be guided by general goals which include reducing the amount of services purchased by Town of Philipstown residents, purchasing from local service providers whenever possible, and working to reduce the local GHG impacts of primary services like healthcare, entertainment, and education.

10 Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

11 Jones, C. (2005). A lifecycle assessment of US household consumption: The methodology and inspiration behind the "consumer footprint calculator." UC Berkeley: University of California International and Area Studies. Retrieved from: https://escholarship.org/uc/item/1fb4q9bb

12 Morley, J., Widdicks, K. & Hazas, M. (2018). Digitalisation, energy and data demand: The impact of internet traffic on overall and peak electricity consumption. Energy Research & Social Science, 38; 128-137. https://doi.org/10.1016/j.erss.2018.01.018

13 Centers for Medicare & Medicaid Services. (2018). National Health Expenditure Fact Sheet. Retrieved from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet

14 Eckelman, M.J. & Sherman, J.D. (2018). Estimated global disease burden from US health care sector greenhouse gas emissions. American Journal of Public Health, 108(Suppl 2): S120-S122. Doi:10.2105/AJPH.2017.303846

15 Eckelman, M.J. & Sherman, J. (2016). Environmental impacts of the US health care system and effects on public health. PLOS ONE. doi: https://doi.org/10.1371/journal.pone.0157014

16 Eckelman, M.J. & Sherman, J. (2016). Environmental impacts of the US health care system and effects on public health. PLOS ONE. doi: https://doi.org/10.1371/journal.pone.0157014

17 Morley, J., Widdicks, K. & Hazas, M. (2018). Digitalisation, energy and data demand: The impact of internet traffic on overall and peak electricity consumption. Energy Research; Social Science, 38; 128-137. https://doi.org/10.1016/j.erss.2018.01.018

18 Sverdlik, Y. (2016). Here's how much energy all US data centers consume. Retrieved from: https://www.datacenterknowledge.com/archives/2016/06/27/heres-how-much-energy-all-us-data-centers-consume

19 Sinha, P., Schew, W.A., Sawant, A. et al. (2010). Greenhouse gas emissions from US institutions of higher education. Journal of the Air; Waste Management Association. 60(5); 568-573. Doi: 10.3155/1047-3289.60.5.568.

Opportunities for Emissions Reductions: Services

Given that healthcare services are the largest driver of service-based GHG emissions, a community health campaign that focuses on increasing activities which can reduce hospital care, physician and clinical services, and use of prescription drugs for chronic illnesses — such as healthy eating, increased physical activity, early detection and prevention, and efforts to increase community connections in order to reduce isolation — can reduce emissions linked to purchased health services.

As entertainment services are the second largest driver of service-based GHG emissions due primarily to the use of electricity, promoting coordinated community recreational activities — such as "Digital Down" days where people turn off TV or get off-line — can reduce emissions linked to purchased entertainment services.

Local primary and secondary schools can reduce emissions by purchasing electricity from the Hudson Valley Community Power CCA, plan for a transition to lower emission sources for heating and cooling, and encourage low-carbon commuting options for students and transitioning to electric school buses. While the Town of Philipstown doesn't have a higher education institution, local high school students can be prepared to take a leadership role on developing and implementing their schools' climate programming on campus.

As consumption of services is driven by individual spending habits, a community campaign encouraging residents to save more or increase contributions to local organizations and charities — which have lower emissions per dollar compared to other service spending categories — can reduce overall service-based emissions.

CHRISTINE ASHBURN PHOTOGRAPHY

IMPLICATIONS: FOOD

This consumption-based inventory estimates that emissions associated with food purchased by community members is the second leading source of local emissions (37,322 MTC02e and 10.4 MTC02e per household). Purchased food generates 19.4% of Philipstown's community-wide emissions, compared to approximately 15% of emissions of the average US household that result from the purchase of food by US households.[20] Over half of local food-related emissions are generated by the consumption of beef (19,034 MTC02e and 5.3 MTCO2e per household). The other sources of emissions include the consumption of other foods like grains, snack foods, vegetables and grains consumed (7,495 MTC02e and 2.1 MTCO2e per household), other meat (6,538 MTC02e and 1.47 MTCO2e per household), and dairy (4,255 MTC02e and 1.2 MTCO2e per household).

Given that the consumption of beef accounts for over half of local food-related emissions, it is worth exploring how the purchase of different foods from different sources drives GHG emissions. The production of beef has far higher GHG emission intensity compared to other meat and food options. Compared to the production of beef, the production of fish, pork and chicken each produces roughly 90% less carbon emissions. After beef production, snack foods are the food category that has the second highest GHG emission intensity.

A number of factors contribute to the high emissions intensity of beef. Cows are less efficient than other animals at converting animal feed into meat, thus requiring large land area for grazing and growing feed crops and making beef production one of the leading causes of deforestation globally. In addition cows' digestive systems directly produce the GHG methane. According to a recent analysis by the World Resources Institute, cutting US beef consumption by 70% would result in a 35% drop in GHG emissions while cutting US beef consumption by one-third and replacing it with pork or chicken would result in a 15% drop in GHG emissions.[21]

While most emissions associated with food are generated by fossil-fuel dependent production practices, other significant sources of emissions are generated at food processing facilities, during transport (on trucks or even airplanes), in buildings (e.g. grocery stores), and in the waste stream (such as the generation of methane from uncomposted food waste at landfills).[22] In recent research conducted by a local Philipstown college student, supply chain emissions of one brand of conventionally grown pork purchased at the local chain supermarket was nearly four times greater than the organically grown option at a local butcher.[23] Shortening the supply chain between where a food is produced and where it is ultimately consumed is critical to lowering food related emissions.

[20] Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

[21] Ranganathan, J., Vennard, D., White, R., et al. (2016). Shifting diets for a sustainable food future. World Resources Institute. Retrieved from: https://wriorg.s3.amazonaws.com/s3fs-public/Shifting_Diets_for_a_Sustainable_Food_Future_1.pdf

[22] Broekhoff, D., Erickson, P. & Piggot, G. (2019). Estimating consumption-based greenhouse gas emissions at the city scale: A guide for local governments. Retrieved from: https://www.sei.org/wp-content/uploads/2019/03/estimating-consumption-based-greenhouse-gas-emissions.pdf

[23] Ptacek, Anya. A Comparison of Local vs. Conventional Organic Meat Systems on the Environment. Unpublished manuscript.

Opportunities for Emissions Reductions: Food

Given that beef consumption is responsible for more than half of the Town of Philipstown's food-related emissions, a community initiative that encourages residents to lower beef consumption and eat alternative meats, legumes, or vegetables would have the greatest impact in reducing emissions.

As Foodtown is the only local supermarket chain in the Town of Philipstown and the place where the majority of residents purchase their food, working with ownership to expand and highlight locally-sourced food options — starting with creating a "Made in the Hudson Valley" aisle, for example — would significantly reduce emissions.

Encourage Philipstown residents to shop for food sourced locally - for example, from the farmers market, local CSA (community supported agriculture) subscriptions, and other local food purveyors, such as butchers, cheesemongers, bakers, etc.

Encourage the growth of local food production in the Town of Philipstown by utilizing public properties and conserved lands for agriculture, encouraging and training community members to grow their own food using regenerative agricultural practices, and adopting local policies that encourage and protect food production.

Encourage local institutions that serve large numbers of people, such as local schools, Graymoor, and local restaurants to source from local food producers.

IMPLICATIONS: HOME HEATING, CONSTRUCTION, RENOVATION AND ELECTRICITY

The consumption-based inventory estimates that emissions associated with home heating fuels are the third leading source of local emissions (35,211 MTC02e and 9.8 MTC02e per household). If the categories of home heating, home construction and renovation (7,295 MTC02e and 2.0 MTC02e per household), and non-heating home electricity (6,704 MTC02e and 1.9 MTC02e per household) were combined — given that all these categories have to do with building and maintaining homes — it would be the leading source of GHG emissions in the Town of Philipstown. As a group, these categories generate over a quarter of local emissions (49,210 MTC02e and 13.9 MTC02e per household), roughly equivalent to the average US household.[24]

Home heating-related emissions are determined by specific energy use and heating systems, with nearly two-thirds of Town of Philipstown residents using oil to heat their homes (64%), followed by propane (12%), electric baseboard (7%), wood or wood pellets (7%), electric baseboard (7%), heat pump (5%), and geothermal (1%). Natural gas is not an available heating source locally as building the necessary infrastructure is not in place, compared to 47% of average US households that heat their homes with natural gas and over 60% in cold climates like New York state.[25] Of those respondents to the survey, 22% of households said they will or may replace their heating system in the next five years, with most planning to replace their old system with a heat pump or geothermal, followed by oil and propane.

Home heating-related emissions are generated from the combustion of fuels to heat homes and hot water, age and efficiency of heating system equipment, indirect (i.e. upstream) emissions associated with specific fuel production and transportation, and electricity use and production. Of the fossil fuel energy sources used to heat Town of Philipstown homes, oil has the greatest emissions intensity (10.21 kg CO_2/gallon), followed by Kerosene (10.15 kg CO_2/gallon) and propane (5.59 kg CO_2/gallon).[26] Of the non-fossil fuel related sources used, wood and wood residuals have a high intensity of emissions related to combustion but lower upstream emissions from production.

Home construction and renovation-related emissions are driven primarily by the size of the home, and include the indirect (i.e., upstream) emissions of structural materials such as lumber and concrete as well as materials that are replaced more frequently, such as carpet, roofing, and cabinets.

Home electricity emissions did not include electricity used for heating homes, as those emissions were accounted for in the home heating category. Home electricity emissions were primarily driven by the energy use and indirect (i.e., upstream) emissions associated with producing other appliances in the

[24] Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf
[25] US Energy Information Administration. US households' heating equipment choices are diverse and vary by climate region. (2017). Retrieved from: https://www.eia.gov/todayinenergy/detail.php?id=30672
[26] US Community Protocol, Appendix C. Available for download by contacting ICLEI,USA.

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home which use electricity (such as air conditioners, refrigerators, hot water heaters, washers and dryers, television, and other technology) and the life-cycle factors for all of Central Hudson's electricity generation sources. Counting indirect (i.e., upstream) emissions associated with electricity generation through the consumption-based inventory resulted in local home electricity related emissions that were about 4% higher than the direct emissions factor used in the production-based inventory.[27]

Proven actions that lower the carbon intensity of homes include both retrofits to existing homes and encouraging the construction of smaller and more energy efficient new homes, including better insulation, more energy-efficient heating, cooling, ventilation, and refrigeration systems; efficient LED lighting; passive heating and lighting to take advantage of sunlight; and the purchase of energy-efficient appliances and electronics.[28] Given that the most significant pathway to home-related carbon emissions will include the electrification of home heating, the Town of Philipstown's leadership in establishing the Hudson Valley Power Community Choice Aggregation (CCA) has helped our community move towards renewable electricity and carbon neutrality. Based on consumption based emissions factors (which include emissions from construction of generation facilities), the CCA is estimated to reduce emissions per kWh by 96.5% compared to the Central Hudson generation mix.[29]

CHRISTINE ASHBURN PHOTOGRAPHY

[27] National Renewable Energy Laboratory. Life cycle assessment harmonization. (n.d.). Retrieved from:https://www.nrel.gov/analysis/life-cycle-assessment.html
[28] Environmental Protection Agency. Sources of greenhouse gas emissions. (n.d.). Retrieved from: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[29] Based on estimated CCA electricity supply generation mix of 73% hydro, 22% onshore wind, and 5% solar.

Opportunities for Emissions Reductions: Home Heating, Construction, Renovation and Electricity

The Town of Philipstown is currently developing a local "Building Emissions" campaign in partnership with the Cornell Cooperative Extension's "Community Energy Engagement Program" and Putnam County's "Clean Heating and Cooling Program." This campaign will assist and guide local homeowners and business owners in completing the following three steps (not necessarily in this order): home energy audit to measure what works and what needs improvement in a building, weatherization to reduce undesired air infiltration and to improve insulation, and heating, ventilation and cooling (HVAC) upgrades to increase energy efficiency and reduce emissions from conditioning a home or business. This program will be launched officially in May of 2020 with extensive community outreach to local households and businesses.

The most significant emissions reduction related to Philipstown's homes will come from transitioning existing and new home heating systems from fossil fuel energy sources to electric air source and ground source heat pumps. Residents can make the transition more affordable by taking advantage of the New York State Energy Research and Development Authority (NYSERDA) and Central Hudson heat pump incentives.

Maximizing the energy efficiency of Philipstown's current and future homes by taking advantage of existing state incentives and utility incentives will be necessary to reduce the energy needed to heat and cool homes, reduce home electricity demand, and encourage the use of low carbon intensity building construction materials. In the future, the Town can consider adopting the NYStretch Energy Code – 2020, which is designed to update local energy building codes and is 25% more efficient than the 2018 International Energy Conservation Code.

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As home associated emissions are driven by the size of homes, the Town can encourage the construction of smaller homes. As opposed to many other communities that mandate large homes through the zoning code, the Town of Philipstown's zoning code allows residential units to be built at a minimum of 720 square feet and accessory apartments to be built at 500 square feet.[30] Philipstown could consider incentivizing the development of smaller homes by reducing property tax rates for smaller homes (or increasing property tax rates for larger homes), waiving fees for smaller homes, fast-tracking the permitting process for smaller homes, or exploring zoning changes that allow for multi-family housing in designated areas.

Existing carbon storage in Philipstown's different land uses represent potential sources of future emissions if important carbon sinks or sequestering resources are developed. The Town of Philipstown Planning Board, which is responsible for approving site development plans in Philipstown, could require impact assessments estimating sequestration losses or emissions increases from posed development to accompany site plan applications. Any net emissions increases from site development could be required to be offset locally.

CHRISTINE ASHBURN PHOTOGRAPHY

[30] Town of Philipstown. Article III Land Use District Regulations. Retrieved from: https://ecode360.com/6319061

Ahead of the Game, Philipstown is part of New York's second Community Choice Aggregation (CCA)

As the Margaret Mead saying goes, "*Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has*". In early 2015, a group of Philipstown residents met to discuss how to fight climate change locally. When Cold Spring resident Peter Callaway mentioned Westchester's successful effort to create New York's first Community Choice Aggregation (CCA), the concept reverberated through the group. During the next several years, local nonprofit the Ecological Citizen's Project and Renewable Highlands led the effort to build a coalition of Hudson Valley municipalities to develop the Hudson Valley Community Power CCA. After dozens of presentations to local elected officials and community groups over three years, a core group of forward-thinking municipal leaders — including the Town of Philipstown — passed a local resolution to form a CCA and appointed Joule Community Power as the CCA Administrator.

In July, 2019, more than 35,000 homes and small businesses representing about 85,000 Hudson Valley residents switched over from Central Hudson's default electricity supply — 50% fossil fuels and 30% nuclear at the time — to the CCA's 100% New York State-sourced renewable energy. We estimate that the CCA will reduce electricity emissions by 96.5% compared to Central Hudson's previous generation mix. While this report makes clear that carbon neutrality cannot be achieved without the mass electrification of home heating, cooling, and personal transportation, electrification is an effective strategy only when the sources of electricity we plug into are renewable. Philipstown's CCA is a success story that other local communities and concerned citizens can emulate and serves as a critical step that lays the foundation for future carbon neutrality.

IMPLICATIONS: ON-ROAD TRANSPORTATION

The consumption-based inventory estimates that emissions associated with on-road transportation are the fourth leading source of local emissions (32,048 MTC02e and 9.0 MTC02e per household). These account for 16% of Philipstown's emissions, compared to approximately 28% of emissions of the average US household that result from on-road transportation.[31]

The production-based inventory estimated over 40% higher emissions associated with on-road transportation (45,805 MTC02e and 12.8 MTC02e per household), which would have made it the second leading source of local emissions behind all combined housing categories which follows national trends.[32] We recommend using the consumption-based inventory estimate, as the larger production-based emissions were largely due to emissions produced by pass-through vehicles not driven by community residents.

Car travel emissions are primarily from direct fuel use, although indirect (i.e., upstream) emissions from vehicle manufacturing and fuel production also contribute to overall emissions. Of those respondents to our community survey, the great majority of residents own and drive gasoline vehicles (86%), followed by hybrid vehicles (11%), and electric vehicles (3%). In a positive future trend, of those survey respondents that plan to purchase a new vehicle in the coming year the majority plan to buy a lower emitting vehicle (35% plan to buy an electric vehicle and 30% plan to buy a hybrid gasoline vehicle) and remaining residents plan to buy a conventional gasoline vehicle (35%).

PHOTO CREDIT: LEIGH BAUMANN

[31] Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

[32] Taiebat, M. & Xu, Ming. (2019). 5 charts show how your household drives up global greenhouse gas emissions. PBS News Hour, Sept 21, 2019. Retrieved from: https://www.pbs.org/newshour/science/5-charts-show-how-your-household-drives-up-global-greenhouse-gas-emissions

Opportunities for Emissions Reductions: Transportation

The greatest emissions reductions will be realized by a community transition to electric and hybrid-gasoline vehicles. In order to lower the cost of the transition, residents should be educated about utilizing existing NYSERDA electric car purchase rebates and explore how to use the collective purchasing power of the Hudson Valley Community Power CCA to significantly reduce the price of electric vehicles for Philipstown residents.

While the Town of Philipstown should continue to expand publicly accessible electric vehicle charging infrastructure, studies estimate that nearly 80% of electric vehicle charging will occur at home by 2030.[33] Philipstown could explore making home electric charging infrastructure an element of the building permitting process and encourage residents to take advantage of current NYSERDA charging station incentives (which don't currently offer incentives to single family homes) and Central Hudson incentives.

Move towards county adoption of a Complete Streets policy, which requires participating municipalities to consider the convenience and mobility of all users when developing and implementing transportation projects, encourage the safe use of streets by vehicles and pedestrians, bicyclists, persons with disabilities, seniors, and youth. The Town of Philipstown adopted a Complete Streets local resolution and encouraging Putnam County to adopt Complete Streets would be beneficial given the county has jurisdiction over many community roads.

In order to decrease emissions related to local travel, encourage current efforts to have Putnam County expand the frequency of the Cold Spring Trolley, the number of local stops, and turn it into a year-around travel option for local residents.

[33] Cooper, A. & Schefter, K. (2018). Electric vehicle sales forecast and the charging infrastructure required through 2030. Edison Foundation Institute for Electric Innovation. Retrieved from https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.pdf

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In the 2017 Philipstown Community Congress, "invest in safe biking and walking paths" was voted the top community priority. Since then, a group of community volunteers has established the Philipstown Trails Committee and received a National Parks Service technical assistance grant to begin exploring the feasibility of developing a local biking and walking trail that connects the Cold Spring Metro North station, the Garrison Metro North Station, and other key community points. Building support to develop this trail across a number of institutionally owned and privately owned properties could significantly reduce car use for local trips and promote community health.

To discourage emissions related to owning multiple vehicles and to make electric vehicle use more accessible and affordable, explore creating a community vehicle car-sharing program like other innovative communities.

Explore electrification of local school bus fleet and municipal vehicles.

PHOTO CREDIT: LEIGH BAUMANN

IMPLICATIONS: GOODS

The consumption-based inventory estimates that emissions associated with the purchase of goods by Philipstown residents is the fifth leading source of local emissions (25,644 MTC02e and 7.2 MTC02e per household). These account for 13% of Philipstown's emissions, similar to the approximate 13% of emissions of the average US household.[34]

Emissions related to the purchase of goods are associated with indirect (i.e upstream) emissions generated by production, transportation and distribution, by buildings where goods are stored and sold, and in the waste stream through goods disposal. Categories of conventional goods purchased by US households include clothing, appliances, furniture, electronics and entertainment equipment, furniture, household and garden supplies, home improvement supplies, medical products, paper products, and personal care products. The top five categories of goods with the highest emissions intensity are paper products (2,100 gCO2e), followed by electronics and entertainment equipment (1,279 gCO2e), personal care products (954 gCO2e), clothing (750 gCO2e), and furnishings, appliances, and other household items (614 gCO2e).[35]

The leading categories of goods-related emissions in Philipstown were "other goods" (5.6 MTC02e per household), followed by clothing (1.1 MTC02e per household), furniture (0.3 MTC02e per household), and appliances (0.2 MTC02e per household). Survey respondents estimate spending $1,479 per year on clothing, followed by $497 on furniture, and $304 on appliances. It is not surprising that the highest spending category for Philipstown residents is clothing, given that the average US consumer is purchasing 60% more items of clothing compared to 2000 while keeping each garment half as long.[36]

Philipstown residents report buying most goods new, with 92% of survey respondents reporting they buy appliances used seldom or never, 67% of survey respondents reporting they buy clothing used seldom or never, and 66% of survey respondents reporting they buy furniture used seldom or never. On average, over 70% of overall household goods were purchased outside of Philipstown.

Purchasing goods locally has a number of emissions-related benefits. If goods are made locally — as opposed to goods purchased from global supply chains — the emissions related to transportation are significantly reduced. Independent retail stores are often far smaller than those of large national chains, decreasing associated building-related emissions. Finally, residents can walk, bike, or drive reduced miles to purchase goods at local stores.

[34] Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

[35] Jones, C. & Kammen, D. (2015). A consumption-based greenhouse gas inventory of San Francisco Bay area neighborhoods, cities and counties: Prioritizing climate action for different locations. Berkeley, CA. Retrieved from https://escholarship.org/uc/item/2sn7m83z

[36] Remy, N., Speelman, E., Swartz, S. (2016). Style that's sustainable: A new fast-fashion formula. Mckinsey & Company: New York. Retrieved from https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula#

PHILIPSTOWN INVENTORY REPORT | 2020 | IMPLICATIONS

Opportunities for Emissions Reductions: Goods

Create a collaborative partnership between Philipstown's community organizations to amplify "shop local" efforts of organizations like the Cold Spring Chamber of Commerce, encouraging residents to purchase goods locally in order to contribute to reduced GHG emissions.

Encourage a community campaign to divert high emissions intensity goods from the waste stream towards recycling.

Consider a campaign to encourage residents to purchase fewer goods, more durable goods with longer life uses, locally produced goods, used goods, and to regularly utilize local libraries like Butterfield Library in Cold Spring and Desmond Fish Library in Garrison. This might include a "Made in the Hudson Valley" campaign that identifies local businesses that sell a significant amount of locally made goods, expanding the library model to other goods, as the Desmond Fish Library has discussed doing with tools, and school-based swap days to pass on lightly used children's clothes and toys.

Educate residents on resources that help consumers identify environmentally friendly products associated with lower emissions, such as guides for personal care products, electronics, paper products, food, curated and up-market used clothing, used books, and other related goods.

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PHILIPSTOWN INVENTORY REPORT | 2020 | IMPLICATIONS

IMPLICATIONS: PHILIPSTOWN LAND USE INVENTORY

In many ways the Town of Philipstown is a rural oasis only 60 miles from New York City, with less than 3% of land developed (i.e., buildings, roads, driveways). The remaining land is mostly forested (79.9%), followed by developed open space like lawns and golf courses (7.4%), open water (2.8%), woody wetlands (2.3%), and other land use types (7.3%). This abundance of local natural resources did not happen by chance, but is the legacy of landowners that valued the preservation of nature, the result of the work of conservation organizations like Hudson Highlands Land Trust, Open Space Institute, and Scenic Hudson, local policies passed by municipal leaders to deter over development, and a community culture that values nature.

The land use inventory estimates that our community's natural resources sequester 79,036-86,098 MTCO2e per year. These estimates highlight that the loss of land uses like forests, wetlands, or fields can be the potential source of significant new emissions that make the path to local carbon neutrality more difficult to achieve. In addition to reducing human-induced emissions on our path toward community carbon neutrality, we will need a coordinated plan to protect and maximize the sequestration services of our natural resources.

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IMPLICATIONS: FORESTS

Based on our land use inventory estimates, Philipstown's 26,184 acres of forest lands annually sequester 73,829 MTCO2e, roughly equivalent to 37% of Philipstown's total community-wide emissions each year. In comparison, US forests sequester almost 10% of annual national GHG emissions.[76] As forests make up over three-quarters of Philipstown's current land use, protecting the carbon sequestered and stored in forest lands and adopting proven forest management practices can prevent future emissions and increase carbon sequestration potential.

Of Philipstown's current forest lands, roughly half (51.4%, or 13,935 acres) are already partially or fully conserved as parkland, institutionally owned and conserved properties, or privately owned properties with conservation easements. The majority of remaining forested land is on private property. While any future forest conservation efforts would largely target private property owners in Philipstown, encouraging forest management practices that maximize carbon sequestration would apply community-wide.

Proven forestry practices that can act to remove CO2 and reduce emissions fall into three categories of action: (1) avoiding conversion of forest land to other land uses (deforestation) that store less carbon and have lower rates of removal; (2) converting non-forest land to forest (afforestation/reforestation) by planting trees or facilitating natural regeneration of trees; and (3) modifying forest management practices to increase carbon stocks in forest soils or increase net removals from the atmosphere.

One of the most promising forest practices to increase the carbon removal capacity (i.e., sequestration) of local forests is to target areas that have faced major disturbance (from natural disasters like Hurricane Sandy or wildfires) and tree losses from new pests and disease (like the emerald ash borer) for tree planting efforts. Tree planting efforts should focus on planting species that are local carbon removal

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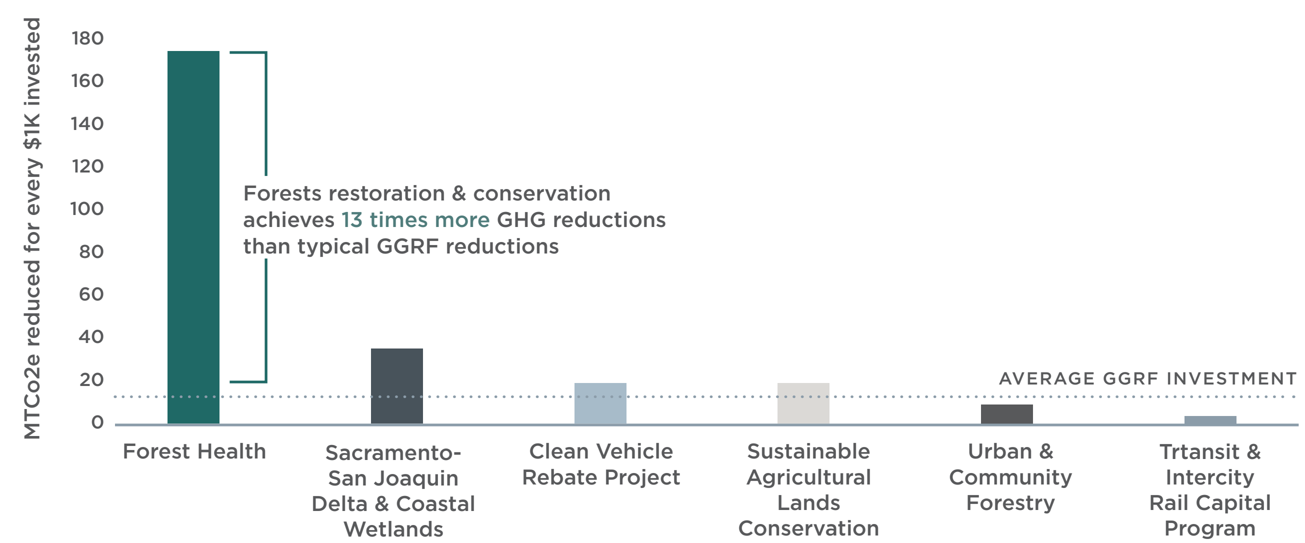
champions, like red oaks and chestnut oaks, and other species that are leading the natural regeneration of New York's forests including American beech, sugar maple, white ash, and red maple.[38] To increase the chances that new tree plantings will thrive or forests can regenerate naturally, area preparations include removing dead, fallen and other mortally damaged trees, removing competing invasive species from the tree planting area, planting larger saplings (instead of seedlings), and protecting saplings from deer browsing through fencing and/or reducing the deer population through expanded partnerships with local hunting organizations in forest areas targeted for replanting.

Additional forest management practices that promote healthier existing forests include improving the ability of forests to resist pests and disease by biological control methods and planned forest diversity, selective thinning of young understory growth to promote higher growth of existing stands of trees, and removal of local invasive species using biological control methods and removal of invasive vines while deterring removal of native vines (such as grape vines and others) that are an important part of the local ecosystem.

Implementing these types of actions have proven to significantly increase the rate of carbon removal (i.e., sequestration) in US forests, with afforestation and reforestation estimated to increase carbon removal by a range of 0.0 to 0.45 Gtons CO2 annually for a period of 50-100 years or more and changed forest management practices estimated to increase carbon removal by a range of 0.03 to 1.6 Gtons per year CO2 for several decades.[39] Compared to other emissions reduction strategies, these actions may prove more affordable and result in greater emissions removals (Figure 10).

FIGURE 10: NATURAL AND WORKING LANDS ARE COST-EFFECTIVE GGRF INVESTMENTS



Source: Empire State Forest Products Association. National context on forests and climate. Presentation by Jed Daley.

37 US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 (2019). Retrieved from https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-chapter-executive-summary.pdf

38 Shirer, R. & Zimmerman, C., (2010). Forest regeneration in New York State. The Nature Conservancy: New York. Retrieved from https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/d/5957/files/2015/03/Forest-Regeneration-in-NYS-shirer-and-zimmerman-29iemne.pdf

39 National Academies of Sciences, Engineering and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259

Opportunities for Sequestration Maximization in Forests

Undertake an inventory to identify which forest areas in Philipstown have lost significant trees due to natural disaster and disease as priority areas for tree planting efforts.

Consider establishing a Philipstown Civilian Conservation Corps (CCC), modeled on the Great Depression era work relief program that planted more than three billion trees and improved forests in over 800 parks nationwide. The Philipstown CCC could employ local high school students and/or low-income community members to plant trees in disturbed areas and employ recommended forest management practices. Funding for the program could come from a local carbon offset action fund, dedicated fees from new development, payment in lieu of taxes from local nonprofit institutions, a local bond, or revenues from developing community owned renewable energy.

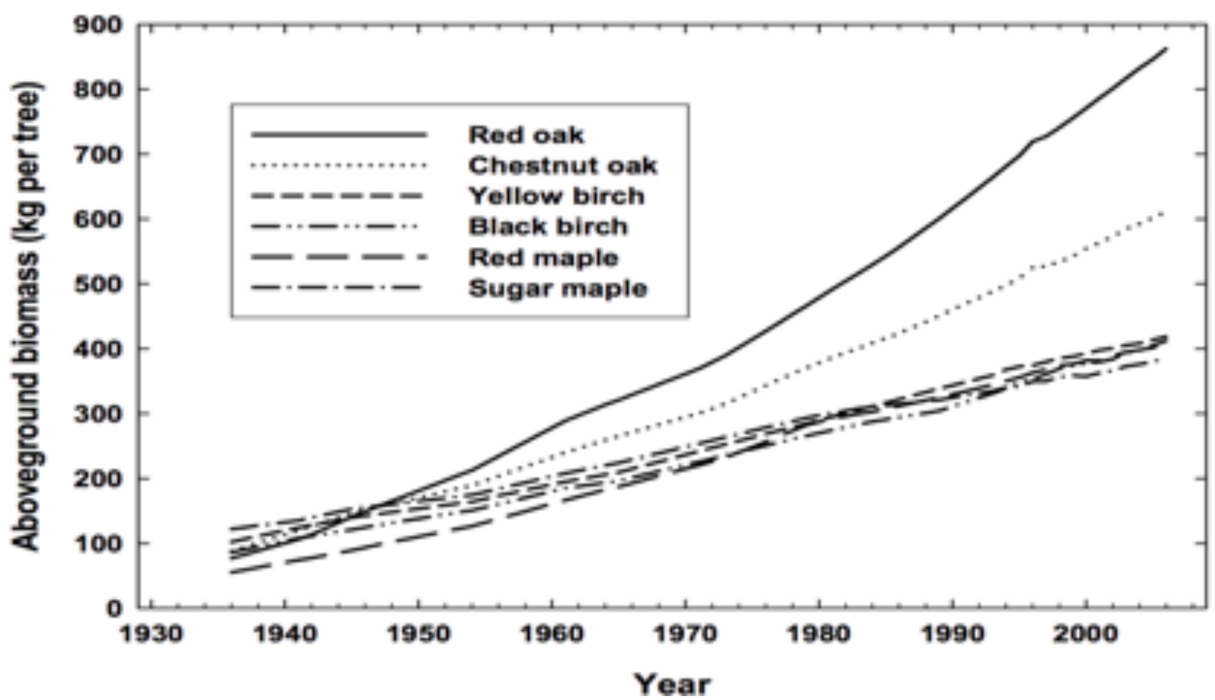
The Town of Philipstown can set annual tree planting goals to restock existing forest lands or encourage tree planting on private properties. Our community could join the Arbor Day Foundation's Community Canopy program, which provides community members with the right trees to plant and identifies the best places to plant them through an online mapping tool. We could also create a community tree-stocking nursery program prioritizing planting of native, diverse, high sequestering species (like Red Oak, see Figure 11, or White Oak), asking for volunteers to grow target tree species saplings at home and community garden spaces for replanting in forest regeneration zones.

The Town of Philipstown could revise our current Timber Harvesting and Forest Management local law so that the cutting or removal of trees for building construction or other property alterations are replaced by tree restocking elsewhere on the property or in community forests.

The Town of Philipstown, local leading conservation organizations, and community partners could conduct an inventory to identify Philipstown's largest and healthiest tree stands on unprotected private properties, utilizing existing Light Detection and Ranging (LIDAR) databases, and target them for individual conservation. In addition, local land conservation organizations can update their conservation easements to reflect forest management practices the maximize carbon sequestration.

Lower Hudson Valley forests are regenerating new trees at such low rates that experts have identified them as requiring management intervention, largely due to overbrowsing by local deer populations.[40] The Town of Philipstown and local conservation organizations can expand partnerships with local hunting organizations to expand deer control efforts in forest areas targeted for replanting.

FIGURE 11: AVERAGE ABOVEGROUND BIOMASS PER TREE OF VARIOUS SPECIES



Source: Schuster, W.S.F., Griffin, K.L., Roth, H., et a.. (2008). Changes in composition, structure and aboveground biomass over 76 years (1930-2006) in the Black Rock Forest, Hudson Highlands, southeastern NYS. Tree Physiology, 28, 537-549.

[40] Shirer, R. & Zimmerman, C., (2010). Forest regeneration in New York State. The Nature Conservancy: New York. Retrieved from https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/d/5957/files/2015/03/Forest-Regeneration-in-NYS-shirer-and-zimmerman-29iemne.pdf

IMPLICATIONS: WETLANDS

Based on our land use inventory estimates, Philipstown's 1,688 acres of non-open water wetlands (i.e., ponds, lakes, marsh, woody wetland, and emergent herbaceous wetland) annually sequester between 2,982 and 5,318 MTCO2/m^2/year. The open water of the Hudson River emits an estimated 240 MTCO2e/m^2/year. Wetlands are incredibly efficient at storing and sequestering carbon, with wetlands estimated to hold 20%-30% of global soil carbon despite occupying only 5–8% of global land surface.[41] Philipstown wetlands are part of the Eastern Mountains and Upper Midwest wetlands region, which have the highest national carbon storage estimates and account for nearly half of wetland carbon in the US.[42] As wetlands contain the highest carbon stocks and sequestering potential per unit area of any eco systems,[43] protecting Philipstown's wetlands from degradation or development ensures they will not reduce naturally-occurring sequestration rates or become a source of new emissions. Figure 12 displays Philipstown's wetlands as classified by the 2016 National Wetlands Inventory.

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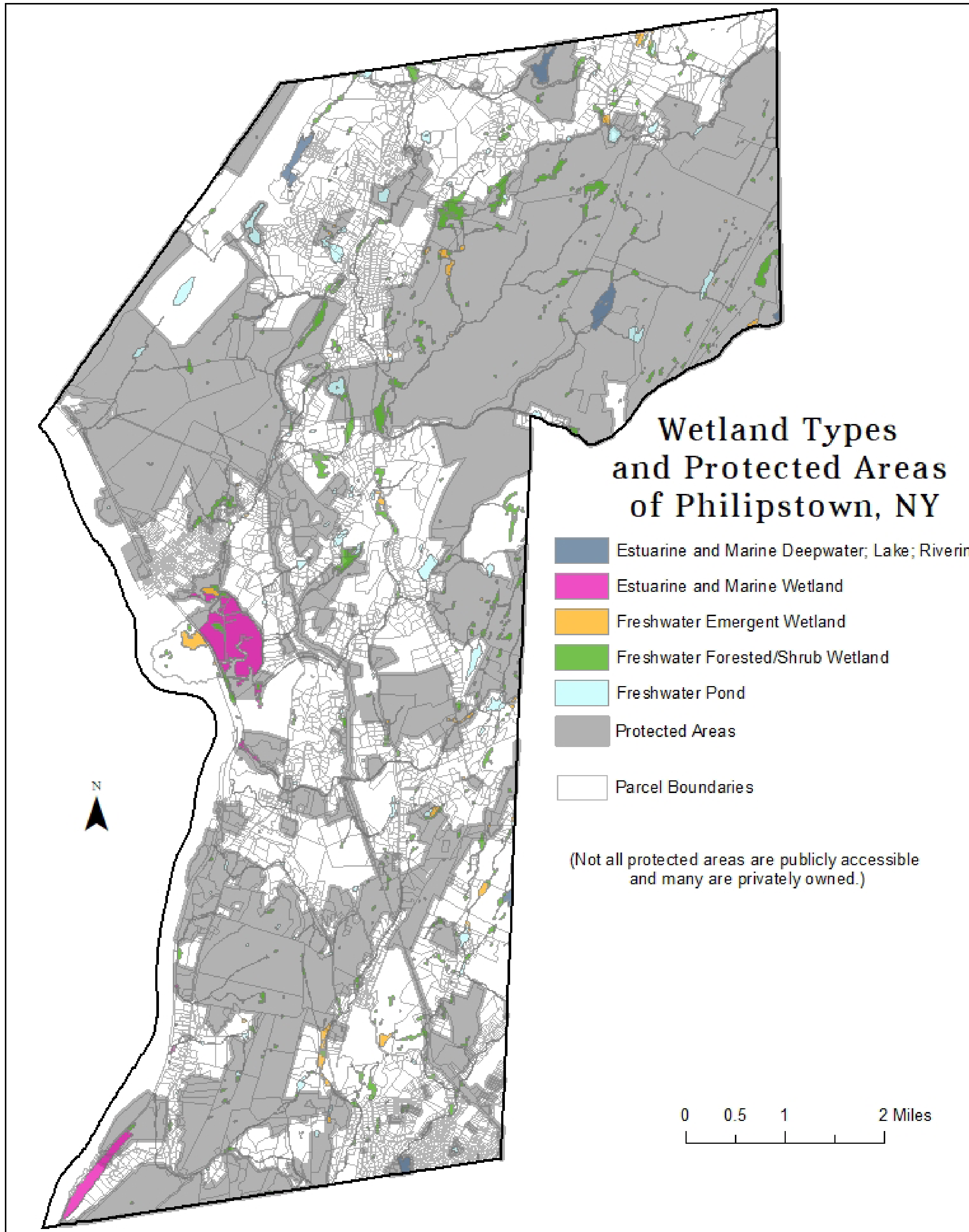
[41] Nahlik, A.M. % Fennessy, M.S. (2016). Carbon storage in Us wetlands. Nature Communications, 7, 13835.
[42] Nahlik, A.M. & Fennessy, M.S. (2016). Carbon storage in Us wetlands. Nature Communications, 7, 13835.
[43] National Academies of Sciences, Engineering and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259

FIGURE 12: TOWN OF PHILIPSTOWN'S LAND USE/LAND COVER OF WETLANDS, NWI (2016)



Source: New York Protected Areas Database (2020), Open Space Institute, Scenic Hudson, Hudson Highlands Land Trust. National Wetlands Inventory - Version 2 - Surface Waters and Wetlands Inventory U.S. Fish and Wildlife Service Oct 2019.

Over 80% (1,407 acres) of Philipstown's wetlands are freshwater inland wetlands and are estimated to hold 85-95% of wetland carbon sequestered in Philipstown. Studies have shown that heavy human disturbance of wetlands — such as housing or commercial development, drainage, proximity to paved areas, or major disturbance to the natural habitat surrounding the wetland — can cut wetland carbon stocks by over 40% and pump new emissions into the atmosphere.[44] Of Philipstown's freshwater inland wetlands, 36% are currently protected or conserved (Figure 12).

Beyond the protection of existing wetlands through targeted conservation, forward-thinking freshwater inland wetland managers are attempting to maintain and increase wetlands carbon sequestration and storage. These practices include wetlands ecosystem restoration by removing invasive species from wetlands areas and replanting native species, using water management to ensure existing wetlands are flooded periodically, and efforts to create new wetlands and ponds.[45]

Philipstown has 281 acres of estuarine wetland (e.g. marine wetland) — Manitou Marsh and Constitution Marsh — with a mix of water that is both saltwater tide and freshwater from the Hudson River. Philipstown's marine wetlands are estimated to annually sequester between 500-1,126 MTCO2e. These tidal wetlands are among the most productive regions on Earth, and here in the Northeast US they are estimated to sequester carbon at a rate of 126 +/- 87 g-C/mˆ2/year.[46] Constitution Marsh is protected and managed as part of the Constitution Marsh Audubon Center and Sanctuary. Manitou Marsh is part of the Manitou Point Preserve, currently managed by the Scenic Hudson Land Trust. Of Philipstown's estuarine/marine wetlands 80% are protected or conserved.

Beyond human disturbance, the greatest threat to the carbon storing and removing productivity of tidal wetlands is the erosion and drowning effects of projected sea level rise.[47] In order to reduce the risk of tidal wetland loss from the projected rise of the Hudson River or even plan for gains in tidal wetlands acreage, forward thinking wetlands managers are identifying surrounding upland areas that can be used for wetlands movement and expansion in the future as the Hudson River rises.

Implementing these types of actions have proven to significantly increase the rate of carbon removal (i.e., sequestration) in US forests, with afforestation and reforestation estimated to increase carbon removal by a range of 0.0 to 0.45 Gtons CO2 annually for a period of 50-100 years or more and changed forest management practices estimated to increase carbon removal by a range of 0.03 to 1.6 Gtons per year CO2 for several decades. Compared to other emissions reduction strategies, these actions may prove more affordable and result in greater emissions removals (Figure 10).

[44] National Academies of Sciences, Engineering and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259
[45] US Carbon Cycle Science Program. State of the carbon cycle report. (2018). Retrieved from https://carbon2018.globalchange.gov/
[46] US Carbon Cycle Science Program. State of the carbon cycle report. (2018). Retrieved from https://carbon2018.globalchange.gov/
[47] National Academies of Sciences, Engineering and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259

Opportunities for Preserved Carbon Sequestration in Wetlands

Conduct a community volunteer and local school-driven effort to take depth readings and perform a carbon content analysis of community unprotected wetlands, in order to identify which Philipstown wetlands are the highest priority for future protection and conservation.

Work with local conservation organizations — like the Hudson Highlands Land Trust, Scenic Hudson, and the Open Space Institute — to reach out to owners of properties that contain high value unprotected wetlands to consider protection through a conservation easement.

Approach the Scenic Hudson Land Trust and Constitution Marsh Audubon Center and Sanctuary to learn if efforts are underway to analyze upland areas around Constitution Marsh and Manitou Marsh to allow for future marsh movement and expansion as the Hudson River rises.

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IMPLICATIONS: DEVELOPED OPEN SPACES

Based on our land use inventory estimates, Philipstown's 2,437 acres of developed, open space (i.e., lawns, parks, recreation fields, golf courses) annually sequester between 1,786-5,470 MTC02e. Turf grasses and lawns are the primary plants in our community landscape managed by Philipstown residents, municipal employees, and businesses regularly. These developed, open spaces provide perennial ground cover and can be viewed as perennial grasslands or no till agricultural systems. By maximizing the growth of turfgrass and lawn biomass while minimizing emissions related to lawn and turf management practices, Philipstown's developed, open spaces can be a significant source of increased carbon removal and storage.

If Philipstown residents' lawn and turf management practices follow national trends, half of residents likely practice minimal input management by mowing once a week without irrigation, fertilizer or pesticide use, nearly 40% practice moderate input management by mowing once a week and applying limited fertilizer, irrigation, and pesticide use, and roughly 10% practice heavy input management by hiring a lawns services company that mows once a week, irrigates regularly, and fertilizes and applies pesticides at least four times per year.[48]

The way residents, municipal employees, and businesses manage turf grasses has a significant impact on emissions intensity and potential sequestration rates. The leading source of carbon emissions from minimal and moderate input management practices are those related to mowing with gas powered mowers (12.9–20.6 g/mˆ2/year), followed by indirect emissions associated with purchased fertilizer (0–20.4 g/mˆ2/year), indirect emissions associated with purchased pesticides (0–2.6 g/mˆ2/year), and the energy water pump emissions associated with irrigation systems (0–.3 g/mˆ2/year). High input management practices have far higher carbon costs, driven by higher indirect emissions associated with purchased fertilizer (15.5–49.5 g/mˆ2/year), indirect emissions associated with purchased pesticides (0.8–5.6 g/mˆ2/year), and the energy water pump emissions associated with irrigation systems (1.6 g/mˆ2/year).[49]

While the total carbon sequestration rates of turf grasses and lawns utilizing heavy input management practices have the potential to be a bit higher than other practices at the very upper end of the range, due to lower associated emissions moderate input management practices (64,480–146,400 g/mˆ2/year) have the greatest potential to maximize the carbon sequestration rates of developed, open spaces in Philipstown. Simply encouraging Philipstown residents, municipal employees, and businesses to move towards moderate fertilization, reduced mowing, pest management, and moderate irrigation could increase Philipstown's overall carbon sequestration from developed, open spaces by 25%.[50]

[48] Zirkle, G., Lal, R., Augustin, B. (2011). Modeling carbon sequestration in home lawns. Horticultural Science, 46(5), 808-814.
[49] Zirkle, G., Lal, R., Augustin, B. (2011). Modeling carbon sequestration in home lawns. Horticultural Science, 46(5), 808-814.
[50] Under the assumption that all 50% of those community members practicing minimum input management move to moderate input management, roughly doubling sequestration rates accounting for a 25% increase across all developed, open space lands.

Opportunities for Carbon Sequestration in Developed, Open Spaces

As the carbon sequestration power of turf grasses and lawns comes from the promoting the growth of healthy grasses, encourage Philipstown residents, municipal employees, and businesses to move towards moderate input management practices (moderate fertilization, pest management, and irrigation) while mowing less frequently. This change in practices could increase Philipstown's overall carbon sequestration from developed, open spaces by over 25%.[51] Future community surveys should ask specifically about mowing frequency and related turf and lawn management practices.

Roughly half (52%) of Philipstown residents reported using inorganic products for fertilizers, herbicides or pesticides on their lawns and properties. Encourage residents to use locally-produced and organic fertilizers, use integrated pest management to control pests naturally, or use organic pesticides.

According to household survey results, 70% of households report gas-powered tools. As the carbon emissions related to lawn mowing are the highest source of emissions for conventional management of developed open spaces, encourage Philipstown residents to transition to electric lawn mowers, make commercial grade electric lawn mowers available through tool lending libraries, or encourage the development of commercial or municipal landscaping services employing electric mowers.

[51] Under the assumption that all 50% of those community members practicing minimum input management move to moderate input management, roughly doubling sequestration rates accounting for a 25% increase across all developed, open space lands.

IMPLICATIONS: PASTURE, GRASSLANDS, AND CROPLANDS

Based on our land use inventory estimates, Philipstown's 714 acres of pasture/hay fields, unmanaged grasslands, and croplands annually sequester between 679-1,721 MTC02e. We combined these different land uses into a single category, because maximizing their carbon sequestration and storage potential involves many of the same regenerative agriculture practices.

Regenerative farming practices include moving to no-till soil systems (no overturning and minimal soil disturbance), growing high carbon sequestering cover crops and perennial grasses, improved and natural field fertilization, use of integrated pest management or organic pesticides, and managed livestock grazing. Recent studies show that farms that transition to these types of practices can quadruple the amount of carbon their lands are sequestering and storing[52] and suggest that regenerative management of all global pasture and croplands could sequester 100% of total global annual emissions.[53]

The majority of Philipstown's lands in this category are managed pasture and hay fields (517 acres) and unmanaged grasslands (178 acres). These fields are already no tillage and don't require cover cropping as they are annually covered with vegetation. The proven practices that would increase the carbon sequestration potential of these fields is the conversion of fields to the growth of perennial grasses or legumes that maximize carbon sequestration and additional fertilization with local, organic compost or manure to stimulate growth. Native perennial grasses that grow well in the Hudson Valley are big bluestem, Indian grass and Shelter switchgrass.[54] Switchgrass in particular produces a great deal of biomass (30,000 lb/ac) and stores a massive amount of carbon (14,250 lbs/ac) compared to other alternatives.[55]

It is likely that the majority of these fields are unfertilized, which reduces biomass growth and carbon sequestration potential. Fertilization could be improved by the addition of compost or organic fertilizers, adding legumes to the field mix which fertilize naturally, or introducing livestock to pastures, hay fields and grasslands. Field trials have demonstrated that applying managed intentional rotational techniques that naturally fertilize a field — where livestock graze intensively for a short period on a small temporarily fenced plot of land — produce significantly higher biomass and carbon sequestration rates compared to fields just mown for hay.[56]

While Philipstown does not have a significant amount of farmed land used to cultivate crops (19 acres), we do have many home gardens whose acreage was not estimated by our community survey and an active home gardening community. Many regenerative farming practices that have proven to increase the carbon sequestration and storage potential of land used to cultivate gardens could be applied in our backyards, improving soil health by applying locally produced, organic compost and fertilizer, including planting cover crops at the end of the growing season, mulching and never leaving exposed soil.

Opportunities for Carbon Sequestration Maximization in Pasture, Grasslands, and Croplands

Existing soils with low levels of carbon content have more potential to increase their carbon storing capacity than soils with high levels of carbon content. In order to identify soils that are the highest priority for improved practices, gain permission from property owners to conduct a community volunteer and local school-driven effort to take soil samples and perform a carbon content analysis of our community's largest pastures, grasslands and croplands. At the same time, document the types of grasses and vegetation currently growing in our managed and unmanaged fields.

Work with volunteer property owners to transition existing fields to perennial grasses and support and expand the Philipstown Pollinator Pathway initiative.

Work with local farming organizations and volunteer property owners to experiment with small-scale managed intentional livestock grazing on existing lands, as well as other regenerative farming practices.

Work with local gardening organizations — like the Philipstown Garden Club — to conduct a survey of current household gardening practices, educate residents about regenerative gardening practices, and measure gardening practice improvements and impacts over time.

[52] Project Drawdown. Regenerative annual cropping. (n.d.). Retrieved from https://www.drawdown.org/solutions/regenerative-annual-cropping
[53] Rodale Institute. Regenerative organic agriculture and climate change. (n.d.) Retrieved from https://rodaleinstitute.org/wp-content/uploads/rodale-white-paper.pdf
[54] US Department of Agriculture. Vegetating with native grasses in Northeastern North America. (n.d.). Retrieved from https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/nypmsbk10321.pdf
[55] US Department of Agriculture. Vegetating with native grasses in Northeastern North America. (n.d.). Retrieved from https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/nypmsbk10321.pdf
[56] Center for Integrated Agricultural Systems. Potential carbon sequestration and forage gains with management-intensive rotational grazing. (2015). Retrieved from https://www.cias.wisc.edu/wp-content/uploads/2015/09/ciasrb95final.pdf

IMPLICATIONS: ALL OTHER SECTORS

The remaining sectors account for roughly 8% of Philipstown's emissions. While targeting these sectors may not end up being a priority for mitigation, there are several opportunities for reducing emissions:

- Emissions as a result of solid waste can be reduced by households wasting less in the first place. This can be achieved by buying and consuming less, buying used products rather than new (because they are wrapped in less packaging, for example), and diverting waste out of the waste stream by re-using, recycling or composting.
- The Village of Cold Spring's wastewater treatment plant could reduce emissions by installing solar arrays, thereby converting electricity used from dirty to renewable.
- Air travel should be reduced in order to reduce fossil fuel emissions; this can be achieved by taking less flights or shorter (i.e., short-haul) flights.
- Households, businesses and Town operations should move to locally-produced renewable electricity sources in order to minimize grid losses and emissions that result from transmission and distribution — the longer the distance from source to end-user, the more potential for loss and emissions. This could be in the form of community-owned solar projects, or participating in local community solar programs.
- Refrigerants are some of the most potent GHGs and their leakage into the atmosphere should be prevented at all costs. By the summer of 2020, the Town of Philipstown is planning to launch a "Refrigerant Management Program" in order to reduce leakage into the air of the extremely powerful greenhouse gases used as "refrigerants" - such as R-22, R-134a and R-410a - in our air conditioners, central cooling units, refrigerators, freezers, dehumidifiers, heat pumps and car A/Cs. The program will (a) educate the Philipstown community about how to properly dispose of these appliances without leaking the refrigerants into the air; (b) offer free or low-cost pick-up and proper disposal of these appliances from local homes and businesses; and (c) educate the community about the availability of new replacement appliances that use climate-friendly refrigerants, such as ammonia or isobutane.

IMPLICATIONS: CARBON OFFSETS

Carbon offset purchasing will be necessary for our Town to achieve carbon neutrality by 2040. A carbon offset allows a person or institution to compensate for the carbon emissions they are responsible for producing by investing in offset activities which lead to reductions in emissions, decreased fossil fuel energy use, or increased carbon sequestration and storage by natural resources. Local communities can either purchase carbon offsets as part of their CAP emission reduction goals or develop carbon offset projects purchased by a polluter. Either way, making the economic and environmental benefits of a local carbon offset program a reality will require local communities to develop a carbon offset program framework.

There are existing carbon offset purchasing programs in the United States. As a municipality, Philipstown may look to identify "sister cities" where regenerative or other carbon sequestering work is being undertaken and purchase offsets directly from these sister sites. At the individual household level, residents can look for companies and nonprofits that deal in carbon offsets that are certified by auditors or standards groups like "The Gold Standard" or "Green-e." For example, consider an air travel trip from New York to Los Angeles which is 2,500 miles. According to the International Civil Aviation Organization's carbon emissions calculator, this trip will burn approximately 0.29 metric tons of carbon per one-way trip per passenger. A household's offsets can then be purchased from a credible site with transparent certifications, such as TerraPass.com, which offers carbon offsets at roughly $11 per MTons-C ($5 per 1,000 lbs). A four-person household taking a round-trip NYC-LAX-NYC flight would thus emit an estimated 2.32 MTons-C and have to purchase $25.52 worth of carbon offsets.

One shortfall of these national programs is that the carbon offsetting actions are occurring outside of a local municipality. New York State's Climate Act[57] calls for a net-zero carbon economy by 2050 with 85% of reductions coming from reduced GHG emissions and 15% coming from carbon offsets tied to emissions-reduction or sequestration projects primarily occurring within the State of New York. The Climate Act is exploring requiring that carbon offset projects "be located in the same county, and within 25 linear miles, of the source of emissions," including projects like a/reforestation, wetlands restoration, sustainable management of natural and urban forests or working lands, grasslands, or coastal wetlands, refrigerant management, and installation of greening infrastructure, and that authorized offset projects "represent greenhouse gas equivalent emission reductions or carbon sequestration that are real, additional, verifiable, enforceable, and permanent." In addition, within a year New York State will explore establishing a social cost of carbon that will serve as a monetary estimate of the value of not emitting a ton of greenhouse gas emissions.[58]

[57] New York State Senate Bill S6599. (2019). Retrieved from https://www.nysenate.gov/legislation/bills/2019/s6599
[58] New York State Senate Bill S6599. (2019). Retrieved from https://www.nysenate.gov/legislation/bills/2019/s6599

The Climate Act's potential requirement that carbon be offset by emitters locally means that innovative local communities that create a local carbon offset framework can help lay the groundwork for a future where people in local communities are paid by polluters to take care of the natural resources that support life and adopt behaviors that reduce carbon emissions. Based on recent innovative work in the field,[58] important elements of developing a local carbon offset framework could include:

- Develop a baseline of local carbon sequestration and carbon storage provided by existing natural resources. This will help establish a business-as-usual starting point to compare future carbon offset projects against, helping to address the "additional" mandate of The Climate Act;

- Report on gross emissions reductions and net emissions reductions as part of the CAP, clearly reporting on the emissions reductions resulting from carbon offset activities;

- Develop a local inventory of carbon sequestration and storage opportunities, such as the identified land areas where specific offset projects would be beneficial, types of projects, and who the property owners are;

- Develop a carbon offset funding mechanism to pay for purchased offset projects to meet CAP reduction goals or developed projects to secure carbon offset payment through The Climate Act. The Town could explore the development of a local fund for carbon offsetting, modeling it after the Finger Lakes Climate Fund, which accepts local monetary donations and grants local awards to households to participate in carbon offsetting action;

- Develop practical and regularly maintained methods for measuring and verifying increased carbon sequestration and storage of local carbon offsets projects to prove that they are "real". This might involve working with partners with expertise in each area. For example, Black Rock Forest Consortium has measured increased carbon sequestration of tree re-plantings in local forests for decades using a simple and inexpensive research plot approach and leading wetlands and agricultural experts sample and test for changed carbon content. Carbon sequestration results can be independently audited by an accredited verification body.

- Develop a transparent system to document carbon offset project ownership and status, such as identifying who is responsible for the project, its location and type, how many carbon credits it is assigned over what time period, who is responsible for verification, and who has purchased the credit.

[59] C40 Cities. Defining carbon neutrality for cities and managing residual emissions. (2019). Retrieved from https://c40-production-images.s3.amazonaws.com/researches/images/76_Carbon_neutrality_guidance_for_cities_20190422.original.pdf?1555946416

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This Philipstown inventory is one of the first projects undertaken by a local municipality in New York to establish a baseline of the carbon sequestration and carbon storage value of local natural resources, a key step in establishing a local carbon offset framework. We hope it contributes to the development of the state local carbon offset program and helps other local communities prepare for a future of new economic opportunities through ecological restoration.

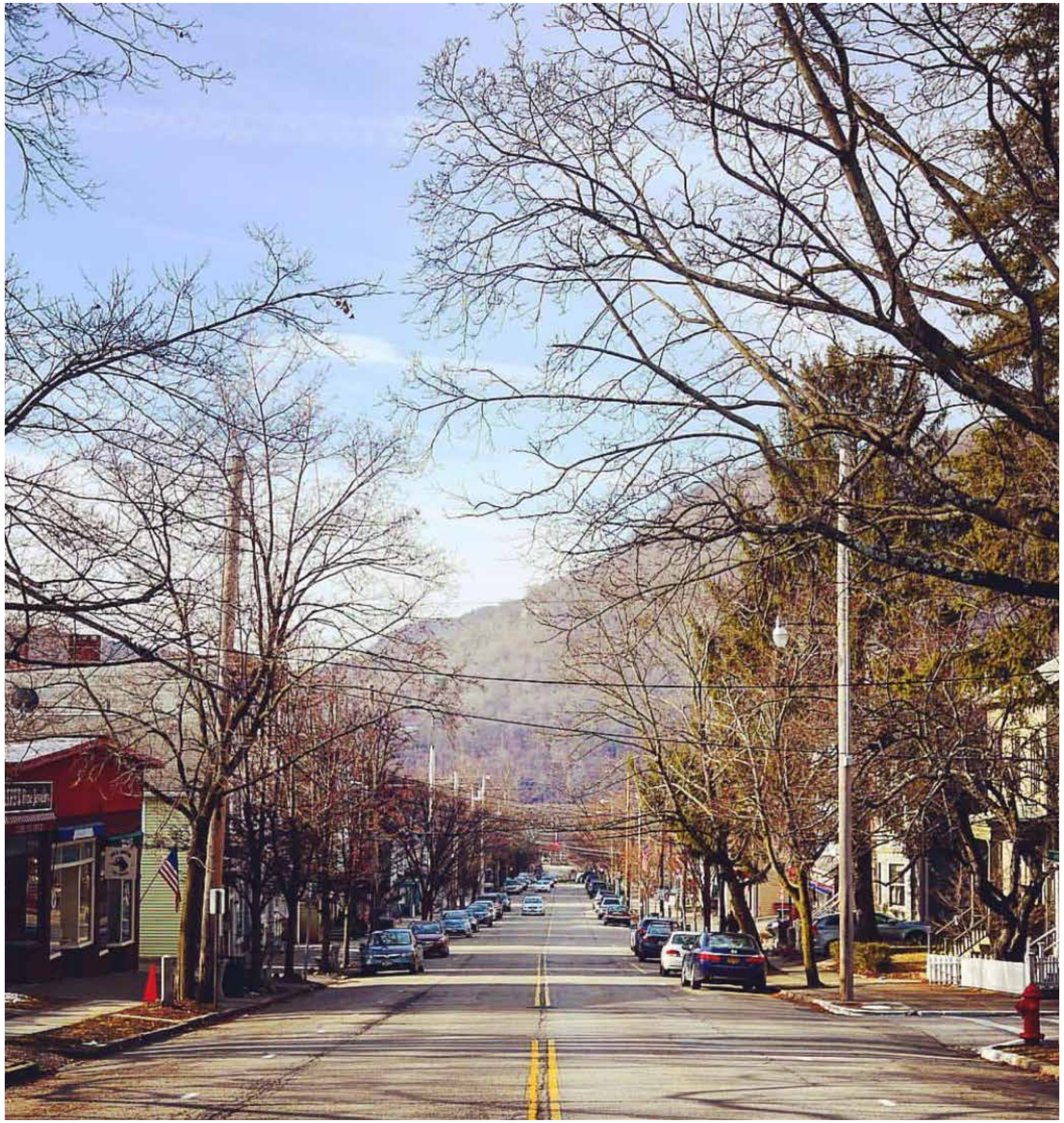

PHOTO CREDIT: LEIGH BAUMANN

IMPLICATIONS: DECIDING HOW TO COUNT LAND USE CARBON REMOVALS AND STORAGE LOCALLY

In the coming months, the Town of Philipstown will have to decide how to account for the emissions and removals of GHG emissions from land uses in establishing its CAP targets. To date, local community GHG inventories have largely ignored measuring land use emissions and removals unless they represent change from a baseline land use, and despite international and national inventories' inclusion of managed lands' carbon sequestration, there is no clear guidance for how local communities should address this issue when setting CAP targets.

For example, in the Environmental Protection Agency's most recent Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017,[60] the United States reports "economy-wide" greenhouse gases (GHGs), i.e., all emissions and removals from all sectors. It separates reporting of gross emissions (from energy, transportation and waste) as one figure and then includes GHG emissions and removals from land use and land use change in a separate figure, resulting in net emissions of the United States. This approach is consistent with the 2006 IPCC Guidelines that established the international framework for national GHG reporting.

Furthermore, with regard to separating human-caused emissions and removals from natural emissions and removals, the IPCC Guidelines suggest countries identify "managed lands" as "land where human interventions and practices have been applied to perform production, ecological or social functions."[61] Emissions and removals from such lands are reported in national GHG inventories and, therefore, can be accounted for when reporting progress towards achievement of GHG emission reduction goals.

In its most recent inventory, the United States reported that GHG removals from managed lands resulted in an 11.3% offset of gross emissions. The great majority of this sequestration, some 85%, is from "forest lands remaining forest lands."[62] The United States currently considers all land, including forests, in the lower 48 states to be managed.[63] The United States emissions reduction targets under the Paris Agreement includes removals from managed lands.[64]

How leading climate action states plan to account for carbon emissions and removals from land in their inventories and subsequently include them in emissions reduction targets is unclear. California currently reports land-related carbon removals through their Natural and Working Lands Inventory (NWI), which is separate from reporting of the California Greenhouse Gas Emissions for 2000 to 2017. Since 2014,

[60] US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 (2019). Retrieved from https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-chapter-executive-summary.pdf

[61] Iversen, P., Lee, D., and Rocha, M. (2014). Understanding land use in the UNFCC. Retrieved from http://www.climateandlandusealliance.org/wp-content/uploads/2015/08/Understanding_Land_Use_in_the_UNFCCC.pdf

[62] US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 (2019). Retrieved from https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-chapter-executive-summary.pdf

[63] Climate and Land Use Alliance. GHG fluxes from forests: An assessment of national GHG estimates and independent research in the context of the Paris Agreement (2017). Retrieved from: http://www.climateandlandusealliance.org/wp-content/uploads/2017/07/GHG_forest_fluxes-main-paper.pdf

[64] United Nations Framework Convention on Climate Change, Nationally Determined Contributions. (2015). Retrieved from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf

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California has included activities related to preserving and increasing carbon removals from forests in their Cap-and-Trade program. Furthermore, the cap-and-trade program has funded more than $600 million in California Climate Investments for activities like forest conservation, forest fire management, wetlands restoration and regenerative soil promotion.[65] California is currently developing the Natural and Working Lands Implementation Plan that will set a carbon removal goal for state land uses to be incorporated in achieving California's 2030 GHG reduction target.

New York does not currently report on carbon emissions and removals from land uses in their New York State Greenhouse Gas Inventory: 1990–2016.[66] In New York's recent Climate Act, which set a goal of reaching economy-wide carbon neutrality by 2050, 15% of total reductions are expected to come from carbon offsets related to land uses. New York — along with California and 15 other states — is part of the United States Climate Alliance Natural and Working Lands Challenge.[67] The Challenge commits member states to improve accounting of carbon emissions and removals from state land uses, identify and advance practices that preserve and increase carbon removals and storage, and integrate land use emissions and removals into state GHG reduction targets by 2020. These developments indicate states are aligning with the national approach (and pushing it further) regarding carbon emissions and removals from land uses.

What does this mean for the Town of Philipstown? The inventory included in this report is consistent with 2016 IPCC Guidelines in that we report both human-caused emissions and estimate carbon emissions and removals from land uses. The Town of Philipstown will have to decide how to define locally managed or unmanaged lands and whether to include a portion or all local carbon removals from land use, land use changes, and forestry as part of their net emissions in its target setting. For example, if the Town decided to count removals from managed lands in their reduction targets as the United States currently does, they might consider a goal of becoming a carbon negative community at an earlier target date.

[65] California Air Resources Board. California 2030 Natural and Working Lands Climate Change Implementation Plan (2018). Retrieved from: https://ww3.arb.ca.gov/cc/natandworkinglands/nwl-implementation-plan-concept-paper.pdf

[66] New York State Greenhouse Gas Inventory: 1990-2016. (2019). Retrieved from https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Greenhouse-Gas-Inventory#:~:text=New%20York%20State%20Greenhouse%20Gas,energy%20and%20non%2Denergy%20sectors.

[67] US Natural and Working Lands Challenge. (n.d.) Retrieved from http://www.usclimatealliance.org/nwlchallenge

Wrapping it Up


CHRISTINE ASHBURN PHOTOGRAPHY

Challenges & Limitations

Throughout this report, we have highlighted the many challenges with attempting to measure a baseline inventory of our Town's GHG emissions using national, state and local data sources, and have also discussed limitations of many of our assumptions, calculations and generalizations. While this local inventory is innovative in its effort to use a local household survey to estimate consumption-based emissions and the carbon sequestration and storage of Philipstown's land uses, it is worth highlighting our major challenges and limitations:

- We had to make use of state- and national data as a proxy for some of our Philipstown household production and consumption estimates;
- Some state- and national data used were from prior years, which may not represent the most valid estimates for the present;
- Our household survey sample was not necessarily representative of the entire Town, over-representing older, higher-educated and higher-income households;
- Household survey data collected did not include some key consumption sector variables, including services consumption and "other goods" consumption; therefore, we used national data to estimate our emissions;
- Land use acreage was estimated using national databases: chiefly the National Land Cover Database and the National Wetlands Inventory. These databases are not updated annually and also have uncertainty in their measurement that impacts our Town's acreage estimates;
- Carbon storage and sequestration estimates must be interpreted with uncertainty, and offer only ranges with varied figures from the literature and practice that make it difficult to select the most appropriate carbon multiplier based on geography and land use type.

Conclusion

The primary purpose of this report is to provide a baseline estimate for net GHG emissions and removals in the Town of Philipstown to inform the Climate Action Plan (CAP) that will be developed in the coming year by the Climate Smart Community task force and partner community organizations. The CAP will outline the policies and actions local government, community partners, and individuals will take to measurably reduce emissions and adapt to unavoidable climate change.

We recommend that the Town of Philipstown adopt this inventory's consumption-based estimate as our official community gross emissions baseline, given that it best localizes the global emissions resulting from our community's actions and unites efforts to promote community health, a growing local economy, environmental stewardship and other sustainability initiatives under the common banner of a collective plan to address climate change.

We also recommend that the Town of Philipstown adopt this inventory's estimate of the carbon sequestration and storage of local natural resources as part of our official community baseline. By doing so, the Town will take the first step to creating a local carbon offset framework, help to protect natural resources by highlighting how land use changes can negatively impact future emission reduction targets, and empower local communities and individuals to take action to maximize carbon sequestration in the natural world around us.

In order to align our efforts to achieve carbon neutrality with international and state efforts, we recommend that the Town of Philipstown adopt a goal of achieving community-wide carbon neutrality by 2040 or becoming a carbon negative community at an earlier target date if all carbon removals from actively managed local land uses are deducted from our gross community-wide emissions. It is an ambitious goal, but one that responds to the reality of climate change being forecast by the overwhelming majority of earth's scientists and experts.

We will have to band together as a community like never before and change our behaviors and actions across many aspects of our lives. But we believe it will build a future where we are healthier, happier, support each other more, and inspire each other and other local communities to embrace the types of change that we know are needed. Now the real work of developing a CAP and launching a community campaign to make measurable progress begins. We hope you will engage in the coming effort — in fact, success is only possible with your help.

Broekhoff, D., Erickson, P., & Piggot, G. (2019). Estimating consumption-based greenhouse gas emissions at the city scale: A guide for local governments. Retrieved from: https://www.sei.org/wp-content/uploads/2019/03/estimating-consumption-based-greenhouse-gas-emissions.pdf

C40 Cities. Consumption-based GHG emissions of C40 cities. (2018). Retrieved from: https://www.c40.org/researches/consumption-based-emissions

C40 Cities. Defining carbon neutrality for cities and managing residual emissions. (2019). Retrieved from https://c40-production-images.s3.amazonaws.com/researches/images/76_Carbon_neutrality_guidance_for_cities_20190422.original.pdf?1555946416

California Air Resources Board. California 2030 Natural and Working Lands Climate Change Implementation Plan (2018). Retrieved from: https://ww3.arb.ca.gov/cc/natandworkinglands/nwl-implementation-plan-concept-paper.pdf

Cascadia Consulting Group. King County greenhouse gas emissions inventory: A 2015 update. (2017). Retrieved from: https://your.kingcounty.gov/dnrp/climate/documents/2015-KC-GHG-inventory.pdf

Center for Integrated Agricultural Systems. Potential carbon sequestration and forage gains with management-intensive rotational grazing. (2015). Retrieved from https://www.cias.wisc.edu/wp-content/uploads/2015/09/ciasrb95final.pdf

Centers for Medicare & Medicaid Services. (2018). National Health Expenditure Fact Sheet. Retrieved from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet

Climate and Land Use Alliance. GHG fluxes from forests: An assessment of national GHG estimates and independent research in the context of the Paris Agreement (2017). Retrieved from: http://www.climateandlandusealliance.org/wp-content/uploads/2017/07/GHG_forest_fluxes-main-paper.pdf

Climate Smart Communities. Certification action. (n.d.). Retrieved from: https://climatesmart.ny.gov/actions-certification/actions/#close

Cooper, A. & Schefter, K. (2018). Electric vehicle sales forecast and the charging infrastructure required through 2030. Edison Foundation Institute for Electric Innovation. Retrieved from https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.pdf

Croton100. Croton 100 Master Plan (2019). Retrieved from http://croton100.org

Eckelman, M.J. & Sherman, J. (2016). Environmental impacts of the US health care system and effects on public health. PLOS ONE. doi: https://doi.org/10.1371/journal.pone.0157014

Eckelman, M.J. & Sherman, J.D. (2018). Estimated global disease burden from US health care sector greenhouse gas emissions. *American Journal of Public Health*, 108(Suppl 2): S120-S122. Doi: 10.2105/AJPH.2017.303846.

Environmental Protection Agency. Sources of greenhouse gas emissions. (n.d.). Retrieved from: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

ICF International. (2012). Mid-Hudson regional greenhouse gas emissions inventory: Final report for Mid-Hudson Tier II Regional greenhouse gas emissions inventory. Retrieved from: https://www.dec.ny.gov/docs/administration_pdf/midhudghginventory.pdf

Intergovernmental Panel on Climate Change. Global warming of 1.5C. (2019). Retrieved from: https://www.ipcc.ch/sr15/

Iversen, P., Lee, D., and Rocha, M. (2014). Understanding land use in the UNFCC. Retrieved fromhttp://www.climateandlandusealliance.org/wp-content/uploads/2015/08/Understanding_Land_Use_in_the_UNFCCC.pdf

Jones, C. (2005). A lifecycle assessment of US household consumption: The methodology and inspiration behind the “consumer footprint calculator.” UC Berkeley: University of California

International and Area Studies. Retrieved from: https://escholarship.org/uc/item/1fb4q9bb

Jones, C. (2016). Quantifying carbon footprint reduction opportunities of US households and communities. DOE Workshop Presentation. Retrieved from https://www4.eere.energy.gov/seeaction/sites/default/files/documents/emv/Carbon%20Footprint%20June%2013%202016.pdf

Jones, C. & Kammen, D. (2015). A consumption-based greenhouse gas inventory of San Francisco Bay area neighborhoods, cities and counties: Prioritizing climate action for different locations. Berkeley, CA. Retrieved from https://escholarship.org/uc/item/2sn7m83z

Morley, J., Widdicks, K. & Hazas, M. (2018). Digitalisation, energy and data demand: The impact of internet traffic on overall and peak electricity consumption. Energy Research & Social Science, 38; 128-137. https://doi.org/10.1016/j.erss.2018.01.018

Nahlik, A.M. & Fennessy, M.S. (2016). Carbon storage in Us wetlands. *Nature Communications*, 7, 13835.

National Academies of Sciences, Engineering and Medicine. (2019). Negative emissions technologies and reliable sequestration: A research agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259

National Renewable Energy Laboratory. Life cycle assessment harmonization. (n.d.). Retrieved from: https://www.nrel.gov/analysis/life-cycle-assessment.html

New York State Greenhouse Gas Inventory: 1990-2016. (2019). Retrieved from https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Greenhouse-Gas-Inventory#:~:text=New%20York%20State%20Greenhouse%20Gas,energy%20and%20non%2Denergy%20sectors.

New York State Senate Bill S6599. (2019). Retrieved from https://www.nysenate.gov/legislation/bills/2019/s6599

Project Drawdown. Regenerative annual cropping. (n.d.). Retrieved from https://www.drawdown.org/solutions/regenerative-annual-cropping

Ptacek, Anya. A Comparison of Local vs. Conventional Organic Meat Systems on the Environment. Unpublished manuscript.

Ranganathan, J., Vennard, D., White, R., et al. (2016). Shifting diets for a sustainable food future. World Resources Institute. Retrieved from: https://wriorg.s3.amazonaws.com/s3fs-public/Shifting_Diets_for_a_Sustainable_Food_Future_1.pdf

Remy, N., Speelman, E., Swartz, S. (2016). Style that’s sustainable: A new fast-fashion formula. Mckinsey & Company: New York. Retrieved from https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula#

Rodale Institute. Regenerative organic agriculture and climate change. (n.d.) Retrieved from https://rodaleinstitute.org/wp-content/uploads/rodale-white-paper.pdf

Schuster, W.S.F., Griffin, K.L., Roth, H., et al. (2008). Changes in composition, structure and aboveground biomass over 76 years (1930-2006) in the Black Rock Forest, Hudson Highlands, southeastern NYS. *Tree Physiology*, 28, 537-549.

Shirer, R. & Zimmerman, C., (2010). Forest regeneration in New York State. The Nature Conservancy: New York. Retrieved from https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/d/5957/files/2015/03/Forest-Regeneration-in-NYS-shirer-and-zimmerman-29iemne.pdf

Sinha, P., Schew, W.A., Sawant, A. et al. (2010). Greenhouse gas emissions from US institutions of higher education. *Journal of the Air & Waste Management Association*. 60(5); 568-573. Doi: 10.3155/1047-3289.60.5.568.

Song, K., Qu, S., Taiebat, M. et al. (2019). Scale, distribution and variations of global greenhouse gas emissions driven by US households. *Environment International*, 133(A).
doi:10.1016/j.envint.2019.105137

Sverdlik, Y. (2016). Here’s how much energy all US data centers consume. Retrieved from: https://www.datacenterknowledge.com/archives/2016/06/27/heres-how-much-energy-all-us-data-centers-consume

Taiebat, M. & Xu, Ming. (2019). 5 charts show how your household drives up global greenhouse gas emissions. PBS News Hour, Sept 21, 2019. Retrieved from: https://www.pbs.org/newshour/science/5-charts-show-how-your-household-drives-up-global-greenhouse-gas-emissions

Town of Philipstown. Article III Land Use District Regulations. Retrieved from: https://ecode360.com/6319061

United Nations Framework Convention on Climate Change, Nationally Determined Contributions. (2015). Retrieved from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf

US Carbon Cycle Science Program. State of the carbon cycle report. (2018). Retrieved from https://carbon2018.globalchange.gov/

US Community Protocol, Appendix C. Available for download by contacting ICLEI,USA.

US Department of Agriculture. Vegetating with native grasses in Northeastern North America. (n.d.). Retrieved from https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/nypmsbk10321.pdf

US Energy Information Administration. US households’ heating equipment choices are diverse and vary by climate region. (2017). Retrieved from: https://www.eia.gov/todayinenergy/detail.php?id=30672

US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017 (2019). Retrieved from https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-chapter-executive-summary.pdf

US Natural and Working Lands Challenge. (n.d.) Retrieved from http://www.usclimatealliance.org/nwlchallenge

Zirkle,G., Lal, R., Augustin, B. (2011). Modeling carbon sequestration in home lawns. *Horticultural Science*, 46(5), 808-814.

Appendix A: Complete methodology for the Town of Philipstown GHG baseline inventory

Production-based Accounting: Data Collection and Calculations

Transportation and mobile sources

I. On-road transportation:
We used the USCP (United States Community Protocol) to estimate the following for the transportation factor set in ClearPath for both gasoline and diesel-fueled vehicles: passenger, motorcycle, light truck and heavy truck fuel efficiency (MPG; miles per gallon); CH_4/mi emitted; and N_2O/mi emitted. We used the 2009 New York State (NYS) Department of Transportation (DOT) Mobile CO Emissions Factors for Project-Level Microscale Analysis to estimate the percentages of vehicle type on Philipstown's roadways: 47.6% gasoline passenger vehicles, 0.5% motorcycles, 43.2% gasoline light trucks, 4.0% gasoline heavy trucks, 0.1% diesel passenger vehicles, 1.0% diesel light trucks and 3.7% diesel heavy trucks. There is no transit fleet operating within Philipstown boundaries.

The NYS DOT issues the Roadway Inventory which classifies roadways, provides length of each classification segment within the jurisdiction, and an estimate of the annual average daily traffic (AADT) on that segment. We secured DOT data for Philipstown and the Villages of Cold Spring and Nelsonville. By multiplying road segment lengths by AADT, we get vehicle miles traveled (VMTs) daily.

The vast majority of local road classifications (functional classes 9 and 19) within Philipstown do not have AADT counts in the DOT dataset, therefore the dataset is favoring larger roadways (with lower FC classifications), which have more traffic but do not characterize the within boundary traffic that occurs on our smaller, local roadways. In order to estimate AADT on FC9 and FC19 roadways in Philipstown, Cold Spring and Nelsonville, we averaged the AADT for all FC9 and FC19 roadways, respectively, in Putnam County. We then applied these county-average AADT estimates to each of Philipstown's, Cold Spring's and Nelsonville's FC9 and FC19 roadways.

Totaling the AADT counts within the jurisdiction resulted in daily VMT of 279,898.8, or a total annual VMT of 102,163,054.7.

II. Off-Road Transportation
The *Mid-Hudson GHG Inventory* used 2007 numbers (for a 2010 proxy) on off-road vehicle emissions using the U.S. Environmental Protection Agency's NONROAD emissions model. Emissions are reported for Putnam County. Philipstown residents represent 9.71 percent of Putnam County residents (9,674 of a 99,670 population for the whole of Putnam) in 2010. The County CO_2 emissions were reported at 36,752 metric ton carbon-dioxide equivalent ($MTCO_2e$). This inventory attributes 9.71 percent of the total, 3,567 $MTCO_2e$, to Philipstown.

III. Rail Transportation
Philipstown's jurisdiction includes a rail line on its western border along the Hudson River that carries Amtrak and Metro-North rail services. This inventory assumes freight rail as negligible (a freight rail line runs on the western bank of the Hudson River). In order to calculate emissions for these services, we estimated the total miles of rail service per year, the total gallons of fuel used in these trips and ultimately, the metric tons of CO_2-equivalent.

The rail track distance in Philipstown is 10 miles. Amtrak diesel train-miles per year in 2002 equaled 86,960 miles and total diesel fuel used was 224,190 gallons (Table 2-9, p. 2-13). Metro-North diesel train-miles per year in 2002 equald 283,185 miles along the Hudson Line (Table 2-12 p. 2-16). This inventory uses Table 2-13, p. 2-17 to estimate 3.34 gallons per train-mile, resulting in 945,837.9 gallons of diesel fuel used for the Metro-North service in Philipstown.

Adding total fuel use from both Amtrak and Metro-North service in Philipstown results in 1,170,027.9 gallons of diesel used per year of rail service within Philipstown's jurisdiction. Fuel usage was converted to CO_2e estimates using ICLEI's ClearPath tool.

IV. Water Transportation
Philipstown's western boundary is the Hudson River. Commercial boats pass through the Philipstown portion of the River and there is a ferry that departs Garrison Landing in Philipstown to West Point Military Academy across the River to Orange County. This ferry is in operation from April through May and from August through October and operates on Fridays, Saturdays and Sundays only, running continuous service throughout the day with no set schedule (but usually runs from Garrison Landing when a Metro-North train arrives nearly hourly (approximately 12 round-trip trips daily). We were not able to obtain actual data on the West Point ferry service line mileage or gallons of fuel consumed, so we used the Mid-Hudson Greenhouse Gas Inventory (2010) to estimate emissions. The MHGHG assigns marine off-road emissions to Putnam County at 26,650 $MTCO_2e$. Since all of Putnam's shoreline is in Philipstown, we will use this metric as Philipstown's GHG emissions.

V. Air Transportation
There is no airport located within Philipstown's jurisdiction, so this inventory considers zero emissions from air travel originating from within Philipstown geographic boundaries.

Stationary Fuel Combustion: Residential and Commercial

I. Electricity
To calculate total emissions from residential electricity use, we used data from the 2016 NYS Utility Energy Registry (UER) for Central Hudson Gas & Electric Corporation for the municipalities of Philipstown, Cold Spring and Nelsonville (since the latter two are villages within the boundaries of Philipstown, but are not included in the UER's total for Philipstown). We then applied emissions factors from Central Hudson's electricity profile to calculate total emissions:

SOURCE	PERCENTAGE
Coal	4%
Oil	< 1%
Gas	43%
Nuclear	34%
Hydro	12%
Biomass	<1%
Wind	3%
Solar	< 1%
Renewable Biogas	<1%
Solid Waste	3%

Emission rates came out to the following, based on the above fuel percentages:

EMISSION TYPE	CENTRAL HUDSON EMISSION RATES (lb/MWh)
CO_2	519.68
CH_4	0.03472
N_2O	0.00448
CO_2e	521.808

We used the same methodology to calculate commercial electricity as we did for residential electricity described above, except we used the commercial totals instead.

II. Methane (Natural gas)
No utility methane sales currently are available in Philipstown for residential or commercial, so we were able to skip this emissions source.

III. Wood
To determine emissions from all for heating sources besides electricity, we first had to make some General Heating Fuels Housing Occupancy Adjustments using housing statistics from the 2016 American Community Survey (ACS) for Philipstown and NYS:

Philipstown Occupancy = 3599 (occupied units) / 4280 (total units) = 84% housing occupancy rate.
Occupied Single Family Detached (OSFD) = .84 x 3392 = 2851 houses
Occupied Single Family Attached (OSFA) = .84 x 201 = 169 houses
Occupied Multi-Family (OMF) = .84 x 685 = 575 houses

Once we estimated the number of occupied units in each category we then applied a weighted energy use average for each type of housing unit to calculate our Adjusted Housing Units (HUadj):

Adjusted Housing Units (HUadj) = ((108 MMBTU per year / 108) x 2851) + ((89 / 108) x 169) + ((54 / 108) x 575) = 3278
Philipstown HUadj percentage = 3278 / 3599 = 91.08%

We then repeated this step using state averages from the 2016 American Community Survey in order to calculate the NYS HUadj and HUadj percentage:

NYS Occupancy = 7,266,187 / 8,191,568 = 88.7%
OSFD = 3,043,600
OSFA = 360,506
OMF = 3,861,814
HUadj = 5,271,589
NYS HUadj Percentage = 5,271,589 / 7,266,187 = 72.55%

Now that we had HUadj percentages for both Philipstown and NYS, we could create a ratio to use state heating fuels data to estimate Philipstown heating fuels data for each heating source.

So, for Residential Wood in Philipstown we took the number of households heating with wood from the 2016 American Community Survey for both NYS and Philipstown and multiplied them by the HUadj percentages:
First we took the number of households heating with wood from the 2016 American Community Survey for both NYS and Philipstown and multiplied them by the above HUadj percentages:

NYS HUadj Wood = 144,316 x 0.7255 = 104,701 heating with wood
Philipstown HUadj Wood = 165 x 0.9108 = 150 households heating with wood

Then we calculated the total Wood Use in Philipstown by setting up the following ratio:

Wood Use NYS (taken from the U.S. Energy Information Administration's 2016 Fuel Use Data for NYS) / (NYS HUadj Wood x NYS Heating Degree Days) = Wood Use Philipstown (what we are calculating) / (Philipstown HUadj Wood x Philipstown Heating Degree Days)

Thus, Total Philipstown Wood Use = 13.4 Trillion BTU (Wood Use NYS) / 1,000,000 MMBTU/ Trillion BTU x (150 (Philipstown HUadj Wood x 5517 (Philipstown HDD) / (104,701 (NYS HUadj Wood) x 5642 NYS HDD) = 18,772 MMBTU

This total was then entered into ICLEI's ClearPath calculator to convert the amount of wood used into GHG emissions. The same was done for each of the following heating fuel sources.

For commercial heating fuels, we had no local fuel usage data. We first determined the total square footage of commercial space in Philipstown and NYS. For Philipstown we obtained the total Philipstown commercial square footage from the Town Assessor's Office. For NYS, we multiplied the total workers in NYS (2016 County Business Patterns - American Factfinder) by the national average (since we couldn't find a state average) square feet per worker (2012 EIA Commercial Building Energy Consumption Survey) to calculate the total NYS commercial square footage.

Total workers in Philipstown = 1904 workers (2016 Zip Code Business Patterns - American Factfinder (10516 + 10524 Zip Codes)
Total Philipstown commercial square footage (from Town Assessor's Office) = 2,395,000 ft2
2,395,000 ft2 / 275 commercial sites = 8,709 ft2 / site
2,395,000 / 1904 workers = 1,258 ft2 / worker
Total workers in NYS = 8,178,455 (2016 County Business Patterns - American Factfinder)
Mean square feet per worker (National average since we could not find a NYS average) = 936 ft2 / worker (2012 EIA Commercial Building Energy Consumption Survey)

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Total NYS commercial square footage = 8,178,455 workers x 936 ft2 / worker = 7,655,033,880 ft2
Then, since no local data was available on fuel use percentages for Philipstown, we used the same percentages from the 2016 American Community Survey for household fuel use to calculate the commercial square footage for Philipstown wood usage. NYS Fuel Usage Statistics came from the 2012 EIA Commercial Sector Energy Consumption Estimates.

NYS SF Wood = 7,655,033,880 x .02 Wood (ACS Fuel %) = 153,100,678 ft2
Philipstown SF Wood = 2,395,000 ft2 x .046 Wood (ACS Fuel %) = 110,170 ft2
Commercial Wood Use Philipstown = 7,900,000,000,000 BTU / 1,000,000 MMBTU/ Trillion BTU x (110,170 x 5517) / (153,100,678 x 5642) = 5,559 MMBTU

This total was then entered into ICLEI's ClearPath calculator to convert the amount of wood used into GHG emissions. The same was done for each of the following heating fuel sources. In the case of wood, however, emissions were not initially completed due to lack of a wood fuel option within the ClearPath calculator for commercial stationary combustion. An estimate was made using the residential stationary combustion calculator for wood and results were entered as "direct entry in the commercial sector. All other fuel uses were available in both the residential and commercial emissions sections of the ClearPath tool.

IV. Propane
We used the same methods to calculate propane usage as described above with wood, except we inserted propane usage data from the 2016 ACS and 2016 EIA Fuel Use Data for both residential and commercial.

Residential:
NYS HUadj Propane = 261,912 x 0.7255 = 190,017
Philipstown HUadj Propane = 251 x 0.9108 = 229
Propane Use Philipstown = 5,529,000 barrels x 42 gallons/barrel x (229 x 5517) / (190,017 x 5642) = 273,658 gallons

Commercial:
NYS SF Propane = 7,655,033,880 x .036 Propane (2016 ACS Fuel %) = 275,581,220 ft2
Philipstown SF Propane= 2,395,000 ft2 x .07 (2016 ACS Fuel %) = 167,650 ft2
Commercial Propane Use Philipstown = 2,061,000 barrels x 42 gallons / barrel (167,650 x 5517) / (275,581,220 x 5642) = 51,493 gallons

V. Heating oil and kerosene
We used the same methods to calculate heating oil and kerosene usage as described above with wood, except we inserted heating oil and kerosene usage data from the 2016 ACS and 2016 EIA Fuel Use Data. Furthermore, because the American Community Survey combines data for heating oil and kerosene into a single percentage and also includes a category for "other fuel," we combined heating oil, kerosene and other fuel so as to include the percentages of each in the calculations, and then separated heating oil and kerosene at the end. Since we didn't have information on what the "other fuel" is, in order to not overlook it, we considered it as either heating oil or kerosene.

NYS Heating Oil Consumption = 15,511,00 barrels
NYS Kerosene Consumption = 602,000 barrels
Percentage Heating Oil vs Kerosene based on above NYS consumption usage:
Heating Oil = 96.26 % and Kerosene = 3.74%
State HUadj Heating Oil + Kerosene = 1,732,065 x 0.7255 = 1,256,613
State HUadj Heating Oil = 1,209,616
State HUadj Kerosene = 46,997
Philipstown HUadj Oil + Kerosene = 2847 (74.4% heating + 3.4% kerosene + 1.2% other fuel = 79% or 2847 Housing Units) x 0.9108 = 2593
Philipstown HUadj Heating Oil = 2593 x 0.9626 = 2496
Philipstown HUadj Kerosene = 2593 x 0.0374 = 97
Oil Use Philipstown = 15,511,000 barrels (Oil Use State) x 42 gallons/barrel x (2593 (Philipstown HUadj Oil) x 5517 (local HDD)) / (1,209,616 (State HUadj Oil) x 5642 (state HDD))
= 1,365,570 gallons
Kerosene Use Philipstown = 602,000 barrels x 42 gallons/barrel x (97 x 5517) / (46,997 x 5642) = 51,029 gallons

For commercial use, we used the same methods to calculate heating oil and kerosene usage as described above, except we inserted heating oil and kerosene usage data from the 2016 ACS and 2016 EIA Commercial Fuel Use Data. Furthermore, because the American

Community Survey combines data for heating oil and kerosene into a single percentage and also includes a category for "other fuel," we combined heating oil, kerosene and other fuel so as to include the percentages of each in the calculations, and then separated heating oil and kerosene at the end. Since we didn't have information on what the "other fuel" is, in order to not overlook it, we considered it as either heating oil or kerosene.

Philipstown SF Heating Oil + Kerosene = 2,395,000 ft2 x 0.79 Heating Oil / Kerosene / OtherFuel (2016 ACS Household Fuel %) = 1,892,050 ft2
Percentage Heating Oil vs Kerosene based on above NYS consumption usage:
Heating Oil = 96.26 % and Kerosene = 3.74%
Philipstown SF Heating Oil = 1,892,050 ft2 x .9626 = 1,821,287 ft2 of space - Heating Oil
Philipstown SF Kerosene = 1,892,050 ft2 x .0374 = 70,763 ft2 of space - Kerosene
NYS SF Heating OIl + Kerosene = 7,655,033,880 x .238 Heating Oil/Kerosene (2016 ACS Household Fuel %) = 1,821,898,063 ft2
NYS SF Heating Oil = 1,821,898,063 ft2 x .9626 = 1,753,759,076 ft2 of space - Heating Oil
NYS SF Kerosene = 1,821,898,063 ft2 x .0374 = 68,138,988 ft2 of space - Kerosene
Commercial Oil Use Philipstown = 8,095,000 barrels oil x 42 gallons / barrel x (1,821,287 x 5517) / (1,753,759,076 x 5642) = 345,259 gallons
Commercial Kerosene Use Philipstown = 57,000 barrels kerosene x 42 gallons / barrel (70,763 x 5517) / (68,138,988 x 5642) = 2431 gallons

Alternative Approach: Compare number of oil customers at state vs local to get a better ratio to calculate oil… we tried obtaining local customer numbers but were turned down by most local companies, so we decided to take the above approach.

Industrial Energy
There are no sites that are classified as industrial within Philipstown, according to both the EPA's Greenhouse Gas Reporting Program and the NYSDEC's Title V Air Permit Data Set, although there are several "light industry" businesses within Philipstown, which were accounted for in the Commercial Energy section above.

Solid Waste

I. Collection and Transportation Emissions
For the Village of Cold Spring we received municipal data on total mass of solid waste, truck fuel type (diesel) and round-trip mileage for residential, commercial and municipal collection and transportation of solid waste to Wheelabrator Solid Waste Incineration Facility in Peekskill, NY (25 miles). With this information we were able to use ClearPath to calculate total collection and transportation emissions. However, for the rest of Philipstown, which is served by two private companies that declined to share their data, we had to use the following approach:

Based on the 2010 Mid-Hudson GHG Emissions Inventory Average Municipal Solid Waste data for Putnam County: 4.9 lb / person / day x 365.25 days = 1789.725 lb / person / year x 7,724 people (non-Cold Spring population of Philipstown) = 13,823,835.9 lb / year / 2,000 lb / short ton = 6,911.91795 short tons / year (which is the metric we needed to enter into ClearPath). The average round-trip transportation route (estimated from the center of Philipstown to Royal Carting Transfer Station in Fishkill, NY and then to Dutchess County Resource Recovery Agency in Poughkeepsie, NY was 50 miles, which we entered directly into the ClearPath Tool to calculate transportation emissions.

II. Combustion of Solid Waste
As described above, total tons of solid waste was obtained from records just for the Village of Cold Spring, whose waste is sent to Wheelabrator Facility in Westchester for electricity-generating incineration. The rest of Philipstown is covered by two private companies that declined to share their data, so we used the same total solid waste that we calculated above for the remainder of Philipstown.

III. Composting
To calculate the total mass of composted solid waste in Philipstown we used the following approach using data from the EPA's "National Overview: Facts and Figures About Materials, Waste and Recycling." 2015 National Compost Generation: 23.4 million tons / 316,515,012 people (United States population - 2015 ACS) = 0.07393 tons/person x 9695 people (in Philipstown in 2016 according to ACS) = 716.75 tons of compost total.

Water and Wastewater

I. Nitrification-Denitrification Process
Philipstown has one in-boundary wastewater treatment plant, which is located in and managed by the Village of Cold Spring. Although the plant does not use nitrification or denitrification to treat the water, there can still be a small amount of nitrous oxide emissions related to the size of the population served, so in order to calculate emissions from nitrification / denitrification we used the population-based method in ClearPath and added an Industrial / Commercial Discharge Multiplier of 1.25 since the plant also serves commercial facilities within the village (based on the suggested multiplier in the ClearPath tool).

II. Effluent Discharge
Similarly to above, we used the population-based ClearPath method to calculate Nitrous Oxide emissions from effluent discharge from the predominantly aerobic-based treatment system. We also applied the 1.25 Industrial / Commercial Discharge Multiplier as described above.

III. Combustion of Biosolids and Sludge
To calculate the emissions from the combustion of biosolids and sludge from the Cold Spring Wastewater Treatment Plant, which first has its biosolids and sludge trucked to a facility in Beacon, NY, where it is dried and the water content is reduced by 7.5%, and is then trucked to New Jersey for incineration, we first assumed the energy content of dry biosolids to be 8,000 BTU/lb (Renewable Energy Resources: Banking on Biosolids, Page 3, National Association of Clean Water Agencies 2010). Then we gathered data from the treatment plant on the total gallons of sludge trucked to Beacon, and used the NYSDEC's *Converting Gallons of Sludge to Metric Tons* guide to calculate the daily metric tons of dry biosolids.

Dry biosolids average energy = 8,000 BTU / lb x 2204.62 lb / MT = 17.636960 MMBTU / MT

Sludge hauled at 2.5% biosolids = 155,000 gal x 8.34 lb/gal = 1,292,700 lbs x 0.025 (averaging 2-3% to 2.5%) = 32,317.5 lbs dry sludge / 2204.62 lb / MT = 14.65899 MT / year / 365.25 days / year = 0.04013 MT / day

To calculate emissions from the transport of biosolids and sludge, we determined from the treatment plant and the intermediate plant in Beacon the total number of trips per year, the biosolids + sludge tank capacity of each truck, the roundtrip mileage for each trip, and the mileage per gallon of diesel fuel for each truck.

Wastewater Transportation:

155,000 gallons / 7,500 gallons per trip to EarthCare in Beacon = 21 trips x 14.2 miles roundtrip / trip = 298.2 miles / 4.5 miles / gallon diesel truck fuel efficiency = 66.27 gallons diesel from Cold Spring to Beacon
Waste evaporated from 2.5% to 9% concentration = 2.5 x 91% / 9% = 25.28, so if 155,000 gallons x 2.5 % = 3875 gallons, then 3875 x 25.28 / 2.5 = 43,834 gallons at 9% biosolids
From Beacon to NW Bergen County Wastewater Treatment Plant: 43,834 gallons / 6500 gallons / trip = 7 trips x 94.8 miles roundtrip / trip = 663.6 miles / 4.5 miles / gallon diesel = 147.47 gallons diesel
Total diesel usage per year = 66.27 + 147.47 = 213.74 gallons diesel

IV. Septic Systems
We used the population-based ClearPath method to calculate septic emissions for residents and businesses within Philipstown that are not served by the Cold Spring Wastewater Treatment Plant (9,695 - 1,971 = 7,724 population with septic tanks).

Agriculture

I. Enteric Fermentation
Since some Philipstown-scale data was not easily available, to determine agroforestry and land-use emissions, we first obtained cropland acreage, pasture acreage and livestock data from both the 2012 Census of Agriculture for NYS and Putnam County and created pasture and cropland ratios to compare Philipstown to NYS and to Putnam County. We then gathered land use data for Philipstown from NASS GeoData CropScape 2016. Lastly, we used the EPA's State Inventory Tool (SIT) to calculate emissions from enteric fermentation by entering information on cows, horses, sheep, hogs, and goats.

Total Philipstown cropland area: 187.7 acres
Total Philipstown pasture area: 254 acres
Putnam County cropland area = 689.2 acres

Putnam County pasture area = 2227.3 acres
NYS cropland area: 4,329,215.3 acres
NYS pasture area: 1,926,695.6 acres
Philipstown to Putnam cropland ratio = 0.2723
Philipstown to Putnam pasture ratio = 0.1140
Total Philipstown to Putnam farmed land ratio = (441.7 / 2916.5) = 0.1515
Philipstown to NYS cropland ratio = 0.000043
Philipstown to NYS pasture ratio = 0.00013
Total Philipstown to NYS farmed land ratio = (441.7 / 6,255,910.6) = 0.0000706052
Putnam County Market Value of Ag. Products sold = $3,256,000
Philipstown Market Value of Ag. Products Sold = $3,256,000 x 0.1515 = $493,284
Dairy cows: 620,000 x .00013 = 81 (NYS data)
Beef cows: 185 - 81 = 104 (difference)
Total cattle: 1,419,365 x 0.00013 = 185 (NYS data)
Horses: 539 x .1140 = 61 (Putnam data)
Sheep: 133 x .1140 = 15 (Putnam data)
Hogs = 46,000 x 0.00013 = 6 (NYS data)
Goats = 29,300 x 0.00013 = 4 (NYS data)
Total farmed area = 441.7 acres

II. Fertilizer Application
To calculate emissions from fertilizer application we used the following method: USDA's National Agricultural Statistics Service (NASS) lists a total of $28,000 spent on synthetic fertilizer in Putnam in 2012 (Putnam County Profile). We then applied the Philipstown to Putnam County Cropland Ratio from above to calculate Total Philipstown Fertilizer Expenses and entered this data into EPA's State Inventory Tool (SIT) to calculate emissions.

Total Philipstown Fertilizer Expenses: = $28,000 x 0.2723 = $7624 spent on fertilizer / $537 average cost in 2012 per ton of nitrogen fertilizer** = 14.97917 short tons of synthetic fertilizer x 907.185 kg / short ton = 13,589 kg of synthetic fertilizer

III. Manure Treatment and Handling
We entered all of the above data on cows, horses, sheep, hogs and goats into the EPA's State Inventory Tool (SIT) to calculate emissions from manure treatment and handling.

Process and Fugitive Emissions

Ozone-Depleting Substance (ODS) Replacement Emissions
To calculate emissions from substances that have been used to replace Ozone-Depleting Substances, we drew on data from the National ODS Replacement Emissions Data Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 – Industrial Processes and Product Use - Table 4-1. From this data we found that National ODS Replacement Emissions = 159,100,000 MTCO2e / 318,558,162 (National Population - 2016 ACS) = 0.4994 MTCOe / person, and multiplied this by the 2016 population of Philipstown.

Philipstown ODS Replacement Emissions = 9695 people x 0.4994 MTCOe / person = 4842 MTCO2e

Upstream Impacts & Activities

I. Residential and Commercial SF6 Emissions from Transmission and Distribution
To calculate the emissions from the leakage of the greenhouse gas Sulphur Hexafluoride (SF6) from electricity transmission and distribution lines we used the following method: SF6 Transmission and Distribution factor = 4,300,000 MTCO2e (Total National SF6 Emissions*) / 3,762,461,630 MWh (Total National Electricity Sales) = 0.0011 MCO2e SF6 Emissions / MWh. Then we multiplied this factor by the electricity used in Philipstown in both residential and commercial buildings and facilities to calculate the SF6 transmission and distribution emissions.

Residential: 38,400.9 MWh x 0.0011 = 42 MTCO2e

Commercial: 12,648.34 x 0.0011 = 13 MTCO2e

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*From the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 - Industrial Processes and Product Use - Table 4-105: SF6 Emissions from Electric Power Systems and Electrical Equipment Manufacturers

II. Commercial and Residential Grid Loss
To calculate emissions from grid loss for both commercial and residential electricity use, we applied the grid loss factor from the Emissions and Generation Resource Integrated Database (eGRID), and selected the Upstate NY (NYUP) grid, of which Central Hudson Gas & Electric is a part. We then entered this grid-loss factor as well as the amount of commercial and residential electricity used in Philipstown into the ClearPath tool to calculate total grid-loss emissions.

Town of Philipstown Government Operations Emissions
The Town of Philipstown has conducted its own government operations emissions inventory, which will be released as a separate report.

Philipstown Consumption-Based GHG Inventory Methods

Consumption-Based Accounting: Data sources and collection
As indicated above, we utilized the ICLEI ClearPath Tool and the Berkeley CoolClimate Calculator Tool to guide our data collection for consumption-based accounting. The sectors we included in our consumption-based accounting were the following:

- On-road transportation, including car usage, commuting behavior;
- Air travel;
- Household management, including home renovations and landscaping/property management activities;
- Food consumption, including types of foods, servings and where purchased;
- Other household goods consumed, including clothing, furniture, cell phones, appliances and where these items are purchased;
- Stationary energy, including home heating fuel and solar array installations;
- Services consumption, including health care, education and entertainment & recreation.

While these two online tools suggested important variables to collect data on, they relied heavily on national- or state-level estimators, as well as per capita income comparisons, to convert goods and services consumption behaviors into GHG emissions estimates. We decided that collecting actual Philipstown resident data would provide us with more accurate and reliable consumption information for our Town's estimates on the variables that we determined to be most important and actionable. In addition, the local data provides a baseline against which a future survey could identify changes in consumption and associated emissions changes.

Through a short series of meetings with Task Force members and key stakeholders, we identified key variables to include in our consumption inventory, as well as ranked the variables we felt were most important to collect local data on because it was most likely to inform our intervention efforts in the near future. An example of such variables were household lawn/property maintenance practices. Task Force members were concerned both with the types of tools used to maintain properties, as well as the amendments or products being applied to turf/lawns. Another example of such a variable would be refrigerant disposal practices because our Task Force is currently working on an initiative for safe disposal of appliances with refrigerants given that associated chemicals have some of the most potent GHG effects in our atmosphere.

Table A1: Measures matrix for Philipstown Community Survey, 2019.

CONSUMPTION CATEGORY	MEASURE
On-road vehicle emissions	Vehicle ownership/leaseholder Number of vehicles Fuel type Year of vehicle Miles driven (annual) Fuel efficiency
Commuting behavior	What transit use to commute Commute round-trip (weekly)
Air travel	Short, medium and long-haul trips (annual)
Household renovations	Lumber Concrete
Landscaping/property management	Gas-powered tool use Non-organic application use Organic application use Acreage of property managed
Food consumption	Household vegetarians/vegans Meat consumption (per day) Type of meat consumed (%) Where purchase meat Dairy consumption (per day) Where purchase dairy Vegetable/fruit consumption (per day) Where purchase produce Snack food consumption (per day) Where purchase snack foods Household food waste (%) Where food waste goes
Other household goods consumption	Clothing consumption ($/year) Appliance consumption ($/year) Furniture consumption ($/year) Purchase history of used clothing/appliance/furniture Where purchase various household goods (food, personal care products, cleaning products, home improvement products, gifts) Cell phone purchase and disposal history Refrigerator/freezer purchase and disposal history Air conditioning unit purchase and disposal history Carbon offset purchase history
Stationary energy	Solar array installation Home heating fuel/source
Household demographics	Square footage of home Owner/renter % of calendar year in Philipstown home Household size Household income Household tenure in Philipstown Age of respondent Education of respondent Gender identity of respondent
Climate change attitudes	Adapted from Christensen & Knezek (2015): The Climate Change Attitude Survey, International Journal of Environmental & Science Education, 1-(5), 773-788.
Respondent contact information	Name, address (to verify residency in Philipstown) Email/Phone (optional)

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A sub-committee of the Task Force worked with consultant-partners, ICLEI, to create a household survey that was made available to every household within Philipstown. We used questions already used in practice for most standard variables. Questions that had to be designed for purposes specific to this community survey were developed by a trained survey researcher on the Task Force and reviewed by a panel of experts at ICLEI. A full list of the variables included in the household survey is in Table A1.

The household survey was made available online through a web-based Google form and was also available as a downloadable document on the Task Force website. A paper version of the survey was available at the two local libraries, the local senior center, and the Town Hall and Village Halls. We conducted outreach with the three local schools to encourage families to participate in the survey, as well as conducted outreach with local businesses through the Chamber of Commerce and with local non-profit or civic organizations, asking them to encourage their members to participate. We also created a postcard mailer that was mailed to every household in Philipstown reminding them to participate in the survey (Appendix D).

Only persons 18 years or older and who are residents (full or part-time) of Philipstown were eligible to complete the survey. We collected basic demographic information, as well as name and address to verify residency. All responses were kept in a password-protected file that only the survey developer had access to and the data was de-identified once addresses were verified so that all responses are confidential and are used only in the aggregate. The paper-based survey is available from the authors upon request.

Consumption-Based Accounting: Calculations
The household survey provided data on types and amounts of consumption by community residents. This data was combined with emissions factors, usually derived from nationally-recognized data sources, to calculate consumption-based emissions.

Car travel: The vehicle miles and miles-per-gallon data from the survey allowed calculation of gallons of fuel used and direct fuel emissions using the same emissions factor as the production inventory. In addition, the consumption inventory includes upstream emissions from fuel production of 1.6kg CO2e/gallon, and vehicle manufacturing emissions of 58 gCO2e/mile.

Air travel: Average air passenger miles per household were calculated from the survey data using the midpoint of each flight length category. For flights over 2300 miles, the assumed average length was 3500 miles. Factors for emissions per passenger mile based on each flight type (short, medium or long) were used to calculate emissions.

Home heating: Heating fuel usage reported on the survey was multiplied by the direct emissions factors used in the production based inventory. In addition, upstream fuel production emissions of 1.62 kg/gal for heating oil and 1.16 kg/gal for propane were included. Because data is not available on electricity use specific to heating, households using electric baseboard, heat pump or geothermal were assumed to require the same average heat input as households using oil or propane. The heat requirement was converted to kWh using an efficiency of 3.4 btu/kWh for baseboard, 8 btu/kWh for heat pumps, and 11.9 btu/kWh for geothermal heat pumps. In addition, the calculation assumes an 80% efficiency for fuel combustion equipment (oil or propane).

Electricity use: Average per household residential electricity use from the production based inventory was used. The estimated electricity use for heating (as described above) was subtracted to calculate 'other electricity use.' A life cycle electricity emissions factor was calculated using the Central Hudson generation mix, and life cycle factors for each generation type from NREL. The resulting emissions factor of 542.11 lbs CO2e/MWh is about 4% higher than the direct emissions factor used in the production based inventory.

GENERATION SOURCE	COAL	NATURAL GAS	NUCLEAR	HYDRO	WIND	SOLAR
gCO2e/kWh	980	470	10	5	11	45

Home construction: Emissions associated with home construction were calculated using the average square footage reported in the survey and an emissions factor of 0.93 kg CO2/square foot, based on emissions to produce construction materials spread over a 50 year lifetime of the building (while the basic structure may last longer, many materials such as roofing and carpet will be replaced more frequently).

Food: The servings per person reported through the survey were converted to grams and multiplied by the number of people in each household. These were then multiplied by per gram emissions factors for food production. The survey did not ask about grain consumption, so grain consumption per person from USDA data was used.

FOOD TYPE	BEEF	PORK	CHICKEN	FISH
gCO2e/g food	82.1	5.6	8.9	6.2
FOOD TYPE	DAIRY	VEGETABLES	SNACK FOODS	GRAINS
gCO2e/g food	4.3	1.3	13.1	5.1

Emissions factors for most foods were drawn from (Jones and Kammen 2015). Because that study did not include individual factors for beef and pork, the factors for those are drawn from a WRI report. Emissions factors for other food types are roughly similar between the WRI report and (Jones and Kammen 2015). It is worth noting that the WRI report uses a model that accounts for land-use change as well as agricultural production emissions.

Goods and services: The survey provided data on consumption of clothing, and on furniture and appliances. Emissions were calculated using emissions per dollar spent.

GOODS TYPE	CLOTHING	APPLIANCES	FURNITURE
Emissions (gCO2e/$)	750	614	614

For other goods and for services (which the household survey did not collect data on), emissions were calculated using the Berkeley Cool Climate household calculator with household income set to $100,000; these emissions were then multiplied by 1.08 to scale to $108,000/year, median household income for Philipstown in 2017.

Philipstown Land Use Inventory Methods

Carbon Storage and Sequestration: Data sources and Collection
Philipstown is rich in natural resources and has over three-quarters of its land covered in deciduous and evergreen forest. Land use decisions have potential to influence a municipality's carbon storage and sequestration, so we set out to understand a baseline of how our Town's land was classified. We referred to several online databases and local land experts, researchers and non-governmental organizations to create a map of Philipstown.

In March 2019, we organized a convening for leaders of local organizations already invested and participating in measuring carbon storage or sequestration. Following this initial discussion of experts, we began mapping land use by acreage within Philipstown, identifying the following land use categories as critical for understanding carbon storage and sequestration: forests (including deciduous, evergreen and mixed); wetlands (including estuarine/marine deepwater, lakes and ponds, riverines, freshwater woody/forested wetlands, freshwater emergent wetland, estuarine/marine wetlands); grasslands (including developed open space [i.e., turf/lawns], managed pasture/hay and unmanaged pasture/hay); agricultural lands (including cultivated annual and perennial crops); and barren or impervious areas. We also included a way to compare land use categorizations by identified protected areas, conserved areas, zoning categories and tax parcels, which will be useful for future development, conservation and climate mitigation activities.

We used a variety of datasets to create GIS layers for Philipstown, which also provided estimates of area or acreage for the various land categories. The two primary databases we used were the National Land Cover Database (NLCD) and the National Wetlands Inventory (NWI). Additional datasets were also utilized. We worked with two GIS experts to procure clipped data for Philipstown, store data that requires server space and to create a searchable PDF document that allows users to select different layers to investigate land features. This map includes a satellite image from Google Earth as a base layer. The area or acreage of the various land use categories could then be calculated using the GIS shapefile attribute tables (Table A2).

Table A2. Land use/cover databases utilized in this inventory.

DATABASE	YEAR(S)	HOW ACQUIRED	LAND USE CATEGORIES
National Land Cover Database	2001; 2016; and change in land use	Public Use	Open water Woody wetlands Emergent herbaceous wetlands (i.e., marshes)
	2001-2016	Public Use	Developed, open space (e.g., lawns, parks, golf courses) Developed, impervious (e.g., buildings, structures, roads) Barren (rock/sand/clay; vegetation <15%) Forest, deciduous (>75% deciduous trees) Forest, evergreen (>75% evergreen trees) Forest, Mixed (neither deciduous nor evergreen are >75%) Shrub/scrub Grasslands/herbaceous Pasture/hay Cultivated crops
National Wetlands Inventory	2019	Public Use	Estuarine and marine deepwater (i.e., open water) Estuarine and marine wetland (i.e., emergent herbaceous wetland) Freshwater emergent wetland (i.e., emergent herbaceous wetland) Freshwater forested/shrub wetland (i.e., woody wetlands) Freshwater pond (i.e., open water) Lake (i.e., open water) Riverine
New York Protected Areas Database	2019	Public Use	Boundaries of protected areas, including fee-owned properties and easements
National Conservation Easement Database	2018	Public Use	Boundaries of easement properties; note that these properties are not public land
Cropland	2016	Public Use	Cultivated crops grown in Philipstown: Alfalfa, Apple, Christmas trees, Corn, Fallow/idle cropland, Grass/pasture, Oats, Other hay/non-alfalfa, Pears, Rye, Soybeans, Winter wheat
Putnam County Zoning	2018	Acquired from county	Highway commercial district Hamlet mixed use district Hamlet residential Institutional conservation Industrial manufacturing Office commercial/industrial Resource conservation district Rural residential Suburban residential
Putnam County Tax Parcels	2018	Acquired from county	Boundaries and identification of tax parcels
Putnam County Agricultural Districts	2019	Acquired from county	Same as NLCD designations

Each database analysis resulted in slightly different acreages for the various land use types, so we selected the most valid estimates depending on land use category. For forested acreage, we prioritized the NLCD's acreage estimates. For water body or wetlands acreage, we prioritized the National Wetland Inventory. For agricultural acreage, we prioritized Putnam County Agricultural Districts and Cropland databases. For impervious or barren acreage, we prioritized the NLCD's estimates. We also examined the change in land use categorization from 2001 to 2016 using an available NLCD dataset to estimate if changes were emitting (e.g., forested land converted to developed space) or storing/sinking (e.g., grassland planted to orchard or forest).

Carbon Storage and Sequestration: Calculations
In order to estimate carbon storage and sequestration of Philipstown's different land use categories, we utilized size of land use type and a "carbon multiplier" (Table A3). Specifically, we worked with experts in the field to select the most valid carbon multipliers by land use type for:

- Carbon storage - the amount of carbon bound up in carbon pools, usually in the form of biomass (aboveground and belowground living matter), and also includes dead organic matter, soil organic carbon and carbon in harvested wood products, also referred to as carbon stock; and
- Carbon sequestration - the removal of carbon from the atmosphere per year through the process of photosynthesis, also referred to as carbon sinking.

For example, forests absorb carbon from the atmosphere (in the form of carbon dioxide) and store it in carbon pools in the form of biomass, such as in aboveground trees, root systems, undergrowth, forest floor and soils. The annual absorption is referred to as the sequestration rate, which is dependent on many external factors. As these carbon pools increase in size or density, they store more carbon. When these carbon pools decompose or are burned, they release carbon (as carbon dioxide) back into the atmosphere. Other examples of carbon pools include wetland peat, grasslands (including turf, lawns, pastures, hayfields), croplands (including row crops and orchards), soil organic carbon and landfills.

I. Forests

For our forest carbon sequestration multiplier, we used a value of 696.7 gCO2e/m^2/year (190.02 g-C/m2/yr), retrieved from researchers at the Black Rock Forest Consortium (BRFC). The BRFC has been collecting data on carbon content and storage of various tree types in the Black Rock Forest for decades and recognizes this as the most appropriate carbon multiplier on average for mixed forests in the Mid-Hudson Valley region. This carbon multiplier value is then multiplied by the total forested area in Philipstown to arrive at an estimate of carbon sequestered annually in our forests' trees (i.e., aboveground biomass). Soil organic carbon on our forest floors are not included in our estimates of forest sequestration, so our forest estimate can be interpreted as a floor estimate: if we were to measure and include the carbon sequestering of our soil organic carbon in our forest floors, our total sequestration estimate would be significantly higher because soil also serves as a carbon sink.

II. Wetlands

Wetlands are net carbon pools (i.e., stocks): the amount of carbon they sequester in the form of soil organic carbon is greater than their net methane oxidation emissions (Mitsch et al. 2013), and in fact, wetlands hold between 20 and 30 percent of the global soil carbon pool, despite occupying 5-8% of the globe's land surface (Nahlik & Fennessy, 2016). The United States Geological Survey (USGS) Eastern US Carbon Storage Report recommends a wetlands carbon sequestration multiplier of 484.7 g-CO2e/m^2/year (132.2 g-C/m^2/yr). However, sequestration varies by wetland type. For example, Mitsch et al., (2013) found a sequestration rate of 454.7-586.7 g-CO2e/m^2/year (124-160 g-C/m^2/yr) in temperate flow-through wetlands, and ultimately recommended an average multiplier of 432.7 g-CO2e/m^2/year (118 g-C/m^2/yr), cautioning that most carbon retention occurs in tropical/subtropical wetlands. Craft (2007) found sequestration rates for freshwater, brackish and tidal marshes, ranging from 440-990 +/- 73 g-CO2e/m^2/year (140+/-20 g-C/m^2/yr). Turunen et al. (2002) found a sequestration rate of 36.7-168.7 g-CO2e/m^2/year (10-46 g-C/m^2/yr) in temperate North American peatlands. Still another (Mitra et al., 2005) provides a general range for wetlands of 73.3-513.3 g-CO2e/m^2/year (20-140 g-C/m^2/yr). Our local wetland experts at Lamont-Doherty Earth Observatory recommend using the 2018 State of the Carbon Cycle Report which suggests 143-781 g-CO2e/m^2/year (39-213 g-C/m^2/yr) for general wetland sequestration.

Therefore, we will utilize the range of 143-781 g-CO2e/m^2/year (39-213 g-C/m^2/yr) as our sequestration estimate for ponds and freshwater emergent herbaceous wetlands and we will utilize the range of 440-990 g-CO2e/m^2/year (120-270 g-C/m^2/yr) for our tidal wetland/marshes. We recognize that these multipliers vary year-to-year and by wetland type, so any sequestration estimates are only approximations and have high levels of uncertainty.

According to US National Inventory and US Community Protocol, Appendix J, woody wetlands should be classified as forest and therefore have the mixed forest multiplier applied: 696.7 g-CO2e/m^2/yr (190.02 g-C/m^2/yr).

For our wetlands carbon storage multiplier, we referred to a local wetland expert and researcher from Lamont-Doherty Earth Observatory, who has been coring and analyzing wetland peat in the Hudson Valley. The formula for estimating carbon (C) storage in wetlands is

C stored = C content X area of wetland X average peat depth

whereas,

C content = % organic matter loss-on-ignition (LOI) X bulk density X average amount of C in sedge peat

Researchers from Lamont-Doherty supplied us with average loss-on-ignition (LOI), bulk density and amount of carbon in sedge peat from their research in Constitution Marsh and Sutherland Pond and Fen in Black Rock Forest. We caution that there is significant variability in both LOI and bulk density depending on how deep the sample is taken. For example, a core sample near the surface of the peat has a higher LOI and bulk density than a core sample near the bottom of the peat. This is a function of age: a sample near the surface is younger in years and therefore has more organic matter that is burned off during the LOI measurement process. Another example: samples could have high bulk density, but rather than being a result of high organic matter (i.e., carbon) it could be a result of a high concentration of sand or silt. This variability led to a range in carbon content calculated.

To obtain "average peat depth" a small group of Task Force volunteers took to the wetlands with probing sticks to collect actual data on peat depth (Appendix C). We selected 2 of each of the 4 wetland types in our Town (8 sampling sites in total) and probed 7 random sample spots in at each site by inserting probing sticks into the "muck" as far as we could until the sticks reached firm resistance. We then averaged the 7 sample depths for each site and used these as estimates of "average peat depth." Given the high variability in many of these variables which are dependent on wetland type, wetland volume, age of wetland, annual weather patterns, we calculated a range for storage: 6,000 - 69,000 g-C/m^3 (which must be multiplied by an average depth of the wetland peat). We totaled the average area of our wetland types (estuarine/marine wetland [i.e., marshes], woody wetland, emergent herbaceous wetland, and freshwater pond/lakes) from our NWI data and then multiplied that area by the carbon content range and peat depth. This range must be interpreted with caution.

III. Grasslands

Grasslands include developed open spaces, such as lawns, turf, golf courses and parks, as well as pasture or hay. Grasslands are net carbon storing/sequestering with different multipliers applied depending on how the land is managed and cultivated. Current research (Zirkle et al., 2011) on "turf" grass, which includes lawns, parks, golf courses and other developed open spaces, suggests a range of carbon sequestering potential. This includes average carbon accumulation in the form of biomass (i.e., net primary productivity, 5.89+/-1.26 to 12.71+/-2.30 Mg-C/ha per year) and in soil organic carbon dynamic accumulation (0.46+/-0.18 Mg-C/ha per year). The carbon multiplier value applied depends on how the land is managed and cultivated: how often it is mowed, to what length it is mowed, whether and what kind of fertilizers/pesticides/herbicides are applied, and how much it is irrigated, with a goal of maximizing growth above- and belowground as well as maximizing soil organic content. It also includes hidden carbon costs of using gas-powered equipment or fossil fuel-intensive fertilizers/pesticides/herbicides.

Therefore, we apply a range of multipliers according to:

- Minimal input lawns (i.e., mowing once a week without irrigation, fertilizer or pesticide use): 25.4-114.2 g-C/m^2/year,
- "Do-it-yourself" or medium input lawns (i.e., mowing once a week with some irrigation, fertilizer or pesticide inputs): 80.6-183.0 g-C/m^2/year; and
- Best management practice lawns (i.e., use of a lawn care service to engage in mowing and multiple fertilizer applications per year): 51.7-204.3 g-C/m^2/year.

This results in an overall range of 25.4 - 204.3 g-C/m^2/year. National estimates suggest 50 percent of turf is minimal input; 37.5 percent is medium input; and 12.5 percent is best-management practice (Zirkle et al., 2011), so we also applied these weights in calculations.

For unmanaged pasture/hay land use in Philipstown, we applied the multipliers for "minimal input lawns" and for managed grasslands (e.g., for grazing or otherwise) land use in Philipstown, we applied the "medium input" multipliers because they were "mowed" and fertilized by livestock.

For grassland carbon storage estimates, we used 4,200 g-C/m^2, as recommended by the USGS Eastern US Carbon Storage Report. However, we caution against use of this number given the high variability depending on management practices.

IV. Agricultural land

Agricultural land also has unique carbon storing/sequestering potential, depending on how the land is managed and cultivated. Conventional agricultural practices, which include monocropping, tilling soil, concentrated livestock grazing and application of inorganic fertilizers, pesticides, herbicides, can result in land that is a net carbon emitter. However, when regenerative agricultural practices are utilized, the land can be carbon storing/sequestering. Regenerative agriculture is a system of farming that increases biodiversity, improves soil health, improves watersheds and enhances ecosystem functioning. This includes practices such as diversified planting, perennial planting, no or minimal soil tillage, application of compost, cover cropping, and managed livestock grazing.

Carbon multipliers range from 12 -200 g-C/m^2/year, depending on these agricultural practices. According to Terra Genesis International, which promotes regenerative agricultural practices, annual cropping with compost and crop rotation can sequester 200 - 600 g-Carbon/n^2/year, compared with managed grazing (0-400 g-C), silvopasture (300 - 3,400 g-C), perennial crop planting (100 - 2,600 g-C) and agroforestry (300 - 4,100 g-C). For this reason, we report a range for carbon sequestration rate utilizing an estimate for conventionally cultivated (i.e., 12 g-C/m^2/yr) to minimally cover cropped/composted (i.e., 200 g-C/m^2/yr) and interpret results with caution.

For each regenerative practice that is applied to land, there is more carbon storing/sequestering potential. For example, in Philipstown an organic farm that applies annual compost, plants cover crops, and has a diversified crop plan will store less carbon than an organic farm that utilizes all of these practices plus does not till the soil. For carbon storage estimates we utilized 4,200 g-C/m^2, as recommended by the USGS Eastern U.S. Carbon Storage Report. However, we caution against use of this number given the high variability depending on agricultural practices.

V. Settlements and other land uses

"Settlements" consist of developed areas and impervious surfaces and "other land uses" consist of bare soil, rock and barren land. Because these land uses are largely devoid of biomass, soil organic carbon or other carbon pools, their areas are not included in carbon storage, sequestration or emission calculations.

Table A3. Carbon storage and sequestration multipliers by land use type.

LAND USE TYPE	CARBON STORAGE MULTIPLIER	CARBON SEQUESTRATION MULTIPLIER (G-C/M^2/ YEAR)	CARBON SEQUESTRATION MULTIPLIER (G-CO2E/M^2/ YEAR)
Forest (mixed)	N/A	190.0	696.7
Wetland (general: emergent herbaceous wetland; ponds)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	39-213	143-781
Wetland (estuarine marshes)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	120-270	440-990
Wetland (woody wetland)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	190.0	696.7
Wetland (open Hudson River)	N/A	20.6	-75.5
Developed open space (e.g., lawns, golf courses, parks)	4,200 g-C/m^2	25.4-204.3	93.1-749.1
Grasslands (managed pasture/hay)	4,200 g-C/m^2	80.6-183	295.5-671.0
Grasslands (unmanaged pasture/hay)	4,200 g-C/m^2	25.4-114.2	93.1-418.7
Agriculture	4,200 g-C/m^2	12-200	44.0-733.3

VI. Land Use Change Between 2001 and 2016

According to the U.S. Community Protocol, conversions from forest land to other land uses results in net emissions of carbon, while conversions from non-forest land to forest land (i.e., afforestation or reforestation) result in sequestration of carbon. However, calculating changes in carbon stocks between land uses depends on multiple variables, including the forest strata, the non-forest land category, the area converted, the removal or emission factor (i.e., carbon multiplier) for each category, and the number of years since the conversion.

The NLCD provides data on land use changes from 2001 to 2016 in a single database. This database, however, does not indicate which direction the changes occur. We were able to estimate changes in acreage by land use type by subtracting the NLCD-reported acreage of each land use type in 2016 from the NLCD-reported acreage in 2001. We then estimated net emission/sequestration by applying our carbon multipliers to the acreage changes.

Appendix B: Town of Philipstown 2016 GHG Emissions Inventory Summary

GHG Emissions by energy source:

Energy Source	2016 MTCO2e	Energy Cost	%GHG	Cost per MTCO2e
Emp. Commute*	(62.42)	-	-	-
Electricity	89.36	$29,701	13%	$332.35
Fuel Oil	220.37	$29,572	32%	$134.19
Gasoline	175.60	$31,097	25%	$177.09
Diesel	207.99	$32,634	30%	$156.90
Propane	0.69	$218	0%	$316.51
Total:	**694.01**	**$123,222**	**100% $**	**178 (average)**

*Not included in Totals

GHG Emissions by facility:

FACILITY	METRIC TONS CO2e	TONS CO2e/ft^2	ENERGY COST
Recreation Center	161.95	7.85	$30,319
Highway Garage + Trailer	55.37	12.77	$12,555
Town Hall	42.46	8.80	$10,091
Depot Theater	24.86	24.86	$5,056
Aqueduct Rd Pump House	9.04	9.42	$5,117
CVPD Club House	8.26	3.30	$3,206
GLWD Pump House	4.95	51.56	$2,090
Highway Salt Shed	1.33	0.30	$833
CVPD Bath House	0.99	1.32	$732
Howland Dr Pump House	0.41	6.51	$574
Recycling Center	0.28	0.27	$542
Arden Dr Pump House	0.18	2.86	$508
Philipstown Park Welcome Sign	0.12	-	$344
CVPD Stone Barn	0.12	0.09	$366
CVPD Work Shop	0.09	0.10	$354

Appendix C: Wetlands probing data collection (2019).

In order to estimate carbon storage capacity of Philipstown's wetlands, volunteers put on their muck boots and got out their kayaks and went out to probe the depths of some of our wetlands. (Methods explained in the Methods Appendix).

Average probing depths for each wetland category sampled in Philipstown are listed in Table C1. Note that there is a large range of peat/muck depth, even within each category, which suggests that a wetland's value as a carbon storage stock depends highly on the specific wetland. We were unable to calculate carbon stored in our forests and grasslands because we did not have comparable soil organic carbon depth measurements.

Table C1. Wetland probing results in Philipstown (2019)

WETLAND TYPE	WETLAND NAME	AVG. PEAT/MUCK DEPTH (in)*
Estuarine/marine wetland	Constitution Marsh	720
	Manitou Marsh	265.6
Freshwater emergent wetland	Appalachian boardwalk (Route 9/403 intersection)	25.3
	S. Mountain Pass Spur	9.1
Freshwater forested/shrub wetland	Appalachian forest (north of 9/403 intersection)	16.4
	Secor St.	14.6
Freshwater pond/lake	403 pond (south)	356
	James Pond	17.3

*The peat/muck depth for Constitution Marsh was acquired from the Executive Director of the Marsh. All other average depths were sampled by volunteers.